AIRCRAFT NAVIGATION TECHNOLOGY AND ERRORS

HEARING

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

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AIRCRAFT NAVIGATION TECHNOLOGY AND ERRORS

MONDAY, SEPTEMBER 19, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON TRANSPORTATION, AVIATION,
AND MATERIALS,
Washington, D.C.

The subcommittee met, pursuant to call, at 10:10 a.m., in room 2318, Rayburn House Office Building, Hon. Dan Glickman (chairman of the subcommittee) presiding.

Mr. GLICKMAN. Good morning. This morning the committee will examine the issue of aircraft navigation technology and errors.

During the early morning darkness on September 1 of this year, a Korean Air Lines 747 took off from Anchorage, Alaska, bound for Seoul, South Korea. Its intended flight path was along a 50-mile wide airway which runs adjacent to Soviet airspace along the Kamchatka Peninsula, the Kuril Islands, and Sakhalin Island, and then passes to the east of Japan.

Inexplicably, the aircraft strayed some 310 miles north of this path, actually crossing Kamchatka, flying west of the Kurils, and crossing the southern tip of Sakhalin Island where it was intercepted and shot down by Soviet fighters, killing all 269 persons aboard.

The Soviets, of course, claim that KAL 007 was on a spy mission and that this deviation from its usual flight plan was intentional. While this explanation is preposterous, many people have questioned how a modern airliner, with triply redundant inertial navigation systems, plus other backup means for checking its position, could get so far off course.

The subcommittee's preliminary look at this question has indicated that such errors are far more common than generally realized. While few such incidents receive the attention that KAL 007 has, the consequences for air safety could be very important over the long term.

With this in mind, we have asked a group of expert witnesses to assist us today with an examination of aircraft navigation technology and errors. We intend to look not only at the facts surrounding the flight path deviation of KAL 007, but also to probe more deeply into the nature and frequency of navigation errors generally.

The fate of KAL 007 illustrates graphically the absolute dependence that modern airplanes have on highly sophisticated navigational systems. As the subcommittee with jurisdiction over civil avigation technology, we must make sure that those systems are as safe and accurate as possible. We ask ourselves again how an aircraft, with sophisticated technology, could veer so far off course, particularly flying a route so close to known hostile territory.

The questions today must be asked: Has this happened before, not only on this route but on other routes? Is it caused by human error? Is there something wrong with the equipment? Could outside sources have interfered in the operation of the technology, and are there things that can be done in the future to prevent this from happening?

I now call on our ranking member, Mr. Carney.

Mr. **Carney**. Thank you very much, Mr. Chairman.

With the brutal slaying of 269 innocent civilians aboard the Korean Air Lines flight 007, the Russians have shown the world their true nature—cold blooded, paranoid, knee-jerk reactionaries. Now, no matter how often Yuri Andropov writes to young Americans describing the Soviets as peace-loving people, uninterested in the arms race with the West, the world will find it hard to believe anything told to them by the Soviet Union. It is unfathomable to me why any one nation would shoot down an unarmed airliner.

But, Mr. Chairman, that is not why we are here today. Korean Air Lines 007 strayed almost 310 miles north of its intended westbound air traffic polar route, taking it from international into Soviet airspace. Airline route accuracy is something that most of us take for granted in this world of increasingly crowded skies, but I understand that these navigational errors are more common than we might realize. With triple redundant inertial navigation systems and a host of other methods by which to check a position, it is hard for me to see how an airline could have been so far off course. A simple mixup in punching in the digits from way points on the intended route could account for the course inaccuracy that the plane took. And so could it have misalined its course from Anchorage. Each, however, would require an incredible set of mistakes and failures.

Mr. Chairman, it is essential that we avoid mishaps like the Korean Air Line tragedy in all future flights. If we cannot guarantee the airline route accuracy for commercial passengers, the result of this may very well be catastrophic, as it has been before. But it also would cause a substantial decrease in foreign air traffic, especially for flights near the Soviet Union, and that would have a tremendous negative impact on our airline industry, which is the responsibility of this committee.

So I commend you for having these hearings in such quick fashion and I look forward to hearing from our list of panelists so we can address this crucial issue today.

Thank you, Mr. Chairman.

Mr. **Glickman**. Thank you, Mr. Carney.

Mr. Gore, do you have any comments?

Mr. **Gore**. Just briefly, Mr. Chairman.

I, too, want to congratulate you on convening this timely examination of possible malfunctioning in one of our most commonly used navigation systems.

As is tragically the case, on this subcommittee we often seem to have the task of examining the state of technology and of technical expertise in the wake of some air disaster. However, since there is speculation that the inertial navigation system may have contributed to the KAL flight taking the fateful course it did, I can't think of a more opportune moment to check our state-of-the-art in navigation.

As my colleague from New York pointed out, and as we all realize, of course, the proximate cause of this disaster was the Soviet Union. However, I am hopeful that these hearings will tell us whether there is something the Congress can do to improve our research effort in the area of navigation systems and thereby mitigate the likelihood of commercial airliners becoming lost and straying off course.

I also am hopeful that this proceeding can shed some light on what might have transpired in the cockpit of flight 007, since that is a question that is on all our minds. If, in fact, this same system has failed at least 21 times in 5 years, then it is obvious that it is susceptible to failure and some changes are needed. I am hopeful this hearing will result in those changes being made speedily.

Mr. **Glickman**. Thank you, Mr. Gore.

Mr. McCandless, do you have any opening comments?

Mr. **McCandless**. Thank you, Mr. Chairman. I have no statement at this time.

Mr. **Glickman**. Thank you.

Mr. Andrews.

Mr. **Andrews**. Mr. Chairman, I have no statement at this time.

Mr. **Glickman**. OK, thank you.

Our first witness is from NASA, Mr. William Reynard, Manager of the Aviation Safety Reporting System with NASA. It is a pleasure to have you here and you may proceed.

STATEMENT OF WILLIAM D. REYNARD, MANAGER, AVIATION SAFETY REPORTING SYSTEM, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. **Reynard**. Thank you, Mr. Chairman, members of the committee. I appreciate this opportunity to appear before you. I would like to start out with a brief statement regarding what I was able to find in the last few days by looking into our data base, and then essentially will respond to whatever questions you may have.

Mr. **Glickman**. Explain your data base for the record, what you do with this.

Mr. **Reynard**. One of the responsibilities associated with NASA's safety research activities is the Aviation Safety Reporting System, an incident reporting program designed to identify issues and hazards in the national aviation system. The program is administered by NASA for the Federal Aviation Administration under a management and funding agreement initiated in 1975.

Incident reporting has proven to be a logical and effective supplement to established accident investigation procedures and other system-monitoring techniques. As opposed to accidents, which are rare events, incidents occur with predictable regularity. Incidents always leave the participants in a position to help investigators, if they so choose. Accidents usually preclude post-event interaction with the flight crew members. And of subtle importance, incidents rarely give rise to the issues of negligence and liability inherent with most accidents. Therefore, if the event's participants do elect to share their experiences, they are not faced with the added threat of complicating their own or their employer's legal position.

The Aviation Safety Reporting System, ASRS, is a voluntary, confidential, nonpunitive incident reporting program. Because of these characteristics, it has succeeded in obtaining information marked by its honest, self-appraisal of pilot and controller performance as reported by the performers themselves. As a consequence, much of the information in the ASRS data base is unique and represents valuable insight into human performance and aviation system issues.

The ASRS is capable of converting raw incident data into safety information for both short-term and long-term use by the FAA, NASA, NTSB, and other elements of the aviation community. The product of the ASRS is available in the form of issue-specific, deidentified data for use in research conducted outside the ASRS organization reports by the staff, as well as for use regarding safety problems and publication of educational material.

While the ASRS data base contains information dealing with all aspects of aviation operations, the specific category of aircraft navigation systems has produced and continues to yield an assortment of safety issues, particularly those that relate to human errors.

The active ASRS data base currently contains 22,429 incident reports. Of that total, 954 reports, or 4.25 percent of the data base, have been diagnosed by ASRS analysts as having navigation anomalies as the primary problem. The 954 reports were reviewed to determine the issue essential to each incident's development. In 623 cases, 2.78 percent of the total data base, and 65.3 percent of the navigation data set, mismanagement of the navigation system by the flight crew was identified as the primary cause of the occurrence. In the remaining 331 cases, or 1.48 percent of the total data base, and 34.7 percent of the navigation data set, the primary cause of the incident involved a failure of the onboard navigation equipment to function as designed. It should be noted these failures were the result of simple mechanical breakdown or operational failures precipitated by actions of the flight crew. All common types of aircraft navigation systems were represented in the 954 incident report data set used for this analysis.

Let me caution you at this point, that because of the voluntary nature of the ASRS reporting concept, statistics drawn from the data base must be viewed as indicators only and may not represent with absolute accuracy the actual statistics to be drawn from the total operational aviation environment. The fact that these types of events only constitute a small percentage of the ASRS data base, in comparison to the many operations conducted during the 5½ years covered by this data set, supports the conclusion that errors caused by onboard navigation equipment are uncommon events, bordering on the rare.

Aircraft navigation systems are extremely reliable, but they are not foolproof. A characterization of our navigation incident reports would have to conclude that the primary cause of a vast majority of these occurrences was human error. Examples of this human error include the input of incorrect data, failing to select a correct operational mode or auto system, and failure to monitor adequately the dynamic flight environment.

While it is true that navigational equipment is quite reliable, it is incumbent upon the flight crew to monitor both their own performance and that of the equipment. This is necessary to assure that the data used to program the equipment was correct, that the procedures employed by the crew are compatible with the safe operation of the aircraft, and that the equipment is operating as anticipated.

Multiple opportunities for cross-checking the navigation data and equipment are usually available to flight crews. This need for cross-checking and the frequent opportunities to do so are often thwarted by the fact that the navigation equipments' established reliability tends to breed complacency on the part of some flight crew members. This anticipation of correctness illustrates one of the paradoxes of modern technological development, not only in aviation but in many labor-critical activities. As advancements place more sophisticated and efficient electro-mechanical devices in a position to perform routine functions, while at the same time asking the human to monitor those functions, we witness a role reversal of the optimum roles of each of these elements. Human beings are very good at doing things, but they are less efficient than automated devices in monitoring routine continuous activity.

Conversely, over a period of time, automated devices generally perform better in the role of the monitor as opposed to that of the actor. This type of role reversal provides an example of the very real need to recognize the ongoing importance of human factors awareness in industries and activities experiencing rapid technological advancements.

In summary, our data indicate that incidents caused by aircraft navigation systems are rather uncommon. The navigation equipment installed on modern aircraft is extremely reliable. While it is quite possible for the mechanical systems to fail, the greater weight of evidence seems to indicate that when such navigation systems do fail or malfunction, it is usually the result of human error or inattention.

Thank you.

Mr. **Glickman**. Thank you very much for your statement.

In summary, then, you are saying that while the numbers are fairly small in terms of navigational errors as compared with all of the other reported errors on your system, which admittedly is not a statistically accurate system, that, by the way, there could be many, many more unreported problems than what has been reported in the NASA, is that correct?

Mr. **Reynard**. Yes, sir. What we tend to do when we analyze a report like this is to try and extrapolate what the potentials are for this type of thing happening and our not hearing about it. Conversely, we also have to keep in mind the thousands and thousands of flights where the flight goes uneventfully, so that there even isn't any incident to report.

Mr. **Glickman**. So extrapolating out, two things would come out. Of the navigation related problems, even those involving sophisticated machinery on existing aircraft, you say roughly two-thirds of those problems are human caused and on——

Mr. REYNARD. Two-thirds of them are clearly human caused——

Mr. GLICKMAN. Clearly human caused.

Mr. REYNARD. The other third are a combination of the equipment failing or the equipment failing because of something the human did.

Mr. GLICKMAN. OK.

In your reporting system, were there any instances of aircraft that veered off course as far as the Korean aircraft veered off in this particular case?

Mr. REYNARD. The maximum deviation that we have in our data base is 250 miles. That has to do with the misprograming of the way points of the INS.

Mr. GLICKMAN. OK. Are there a series of navigational problems where you had, let's say, further than 100-mile deviations?

Mr. REYNARD. No, the average is less than 100, simply because most flight crews have a routine that is established with regard to cross-checking their position. It is possible to detect that error well under the 100 mile mark.

Mr. GLICKMAN. Based upon the statistical computations that you made, would you believe that the incidence of navigational errors, even if fully reported, would be rather statistically small?

Mr. REYNARD. Oh, definitely.

Mr. GLICKMAN. Now, realizing, of course, that this information that is reported to you is done so anonymously to avoid, I guess, civil or criminal liability——

Mr. REYNARD. As a matter of fact, the system is a confidential one, in that we know the identities of the reporters for a short period of time and can follow up on the report to get what additional data we need. It then becomes anonymous in the sense that we take out all the identities to preserve the integrity of the information so that it can be used effectively for safety purposes by FAA, NASA, NTSB, et cetera.

Mr. GLICKMAN. Then you don't get into the situation of determining whether any particular carriers are more involved with navigational errors than other carriers?

Mr. REYNARD. No, sir. We could not respond to a query which would say "which is the safer?" We simply don't know because we don't retain that——

Mr. GLICKMAN. OK. Can you respond to an inquiry which would indicate which part of the world or which areas of routes are more susceptible to navigational errors than other parts of the world?

Mr. REYNARD. Well, the difficulty there, sir, would be the fact that our data set is made up of almost 99 percent of domestic operations or operations by domestic carriers. A very small percentage is international operations. Consequently, we really wouldn't be able to address that question with any kind of statistical reliability.

Mr. GLICKMAN. Then if a U.S. carrier were flying from Anchorage to Seoul or Tokyo or Hong Kong, they might report an error if there were one, but a Korean carrier probably would not?

Mr. REYNARD. There is less likelihood that the Korean carrier would. We do have several airlines who have shown interest in the ASRS in the sense that they recognize that aviation issues are pretty much international. So when they have a problem, particularly a human factors problem, they will report it to us, even though it may not be a domestic issue.

Mr. **Glickman**. Do you have any theories as to why this airplane could have strayed so far off course?

Mr. **Reynard**. To be quite frank with you, sir, I wouldn't even want to venture a guess. There are so many variables that could exist that until there is more substantive evidence gathered, it would just be a guessing game.

Mr. **Glickman**. Why don't you run through the variables. You mentioned some of them, but I think it would be useful if you could give us all the options that could have happened, that you're aware of.

Mr. **Reynard**. Well, the data that we have indicate that the biggest problem is what, in our category, is referred to as information transfer. In this particular case, what you might have is a way point being programed wrong. You may have a situation where the data that was given to the crew was wrong. I am sure you're familiar with the term "garbage in-garbage out." If you put bad information into the INS, the INS is going to give you bad information back. Quite frankly, our data base would tend to indicate that if, in fact, there was a problem, the greater probabilities would be that it was a human error problem.

Mr. **Glickman**. The INS systems themselves, though, they have backups, don't they?

Mr. **Reynard**. There are several ways of viewing INS's in terms of backup. Some systems have two INS's, they're independent; some of them have three and they're independent. But the basic issue goes back down to what did the crew do with regard to the management of that system.

Theoretically, the crew will put into the INS the way point coordinates independently, and then another member of the crew will check—for instance, the captain will put his way points in, and then the first officer will check what the captain did. The captain will check what the flight engineer did, and the flight engineer will check what the first officer did. If, in fact, something comes up—let's say, for instance, the first officer gets on the airplane first, and they happened to be in a time bind, and programs his INS, and then the other two crew members come in and, instead of entering their numbers independently, they simply copy what the first officer has, if the first officer made a mistake, then the error has been multiplied and you have lost your cross-check function.

Mr. **Glickman**. Now, you talked a little bit about the complacency which may be breeding in some cockpits. Would this be an example of that complacency if there was the mere copying down of previously written coordinates or numbers without independently verifying them?

Mr. **Reynard**. It would certainly be a peripheral example. The data base contains other examples of the system being so incredibly reliable that—when the crew, for instance, changes the operational mode—let's say, for instance, they take it off INS and put it on to, say, some type of heading or manual mode to steer around weather, and then forget to put it back into the INS mode for further navigation, sometimes the complacency of the fact that everything works so fine tends to displace the awareness that maybe we ought to go back and cross-check that. Obviously, when you're out in the middle of the ocean, if everything seems to be working right and you're not cross-checking as you should be, complacency can be a very big problem.

Mr. **Glickman**. My final question to you, do you have any ideas where additional Federal research efforts could be applied to resolve the problems of navigational errors?

Mr. **Reynard**. Well, the data in our data base would indicate that, as part of the greater problem or issue of aviation safety would be a continued emphasis on this issue of human factors. You know, we have extremely reliable aircraft; we've got extremely reliable avionics; we've got an air traffic control system that is probably the best in the world. But we are still trying to put a handle on what it is the human being is capable of doing and, quite frankly, what he is capable of not doing in the sense of the ways he can screw up. Consequently, I think it's imperative, with this growing reliability of the other factors, that we continue to place some emphasis and certainly some attention on the human factors.

Mr. **Glickman**. Thank you.

Mr. Carney.

Mr. **Carney**. Thank you, Mr. Chairman.

If we could focus on air traffic within the continental United States for a moment, maybe I could be more aware of the world picture.

For someone to stray 250 miles—as you mentioned, that was the longest distance that had been reported—over the continental United States, that would take quite an effort, I would think, because I was under the impression that they would be picked up by the ground over the United States when they would be that far off course.

Mr. **Reynard**. Let me clarify one point. The one example of the 250-mile deviation involved an international carrier over the North Atlantic. So, consequently, that was not a domestic operation. It was a domestic carrier in the sense that it was certified here in the United States. But the operation itself was over the North Atlantic.

You're quite right, to get 250 miles off course in the continental United States——

Mr. **Carney**. Would be—I would not want to use the word "impossible," but it would be quite a trick.

Mr. **Reynard**. It sure would.

Mr. **Carney**. You would have to have errors in the cockpit of a great magnitude; you would have to have errors on the ground of great magnitude for that consequence to come about.

Mr. **Reynard**. Yes.

Mr. **Carney**. The way points in continental United States airspace, do they go for distances of 200, 300 miles, or would they be closer to the radial points?

Mr. **Reynard**. From my flying experience, I can't think of a circumstance where, if a crew really wanted to cross-check their navigation system, they couldn't do it as frequently as perhaps once every 50 miles, and probably less than that.

Mr. **Carney**. Where they could take their navigation equipment and point into a radio station——

Mr. Reynard. Well, you've got various means, of course. You've got the very high frequency omnidirectional range, VOR——

Mr. Carney. Right.

Mr. Reynard. You've got distance measuring equipment, which essentially measures the distance to a given point; you've got the radio stations which you can use as a nondirectional beacon. There are many ways of doing it.

As with our air traffic control system, we're very fortunate in this country to have probably the best and the most complex navigational aid system, also. So, consequently, it would take a monumental error on the part of somebody to get very far off track if they're really doing their job.

Mr. Carney. I think that's important. I wouldn't want the people in the United States to think that this type of error is commonplace to great magnitudes over our airspace at any rate. But now the tasks get somewhat difficult when you go over into the international airspace, particularly when you're over water, the great oceans of the world, the checkpoints become farther apart, I would imagine; would that not be correct?

Mr. Reynard. Yes. You've got checkpoints that are further apart and you have navigation systems that aren't nearly as refined as ours. So consequently, what you do is you essentially develop a much greater sense of awareness. Some of the most experienced pilots that exist in the world today exist as a result of operating out of this country into countries where there aren't such navigation systems, and they simply have developed standardized procedures and awareness programs which enable them to do as much cross-checking as is, quite frankly, as is humanly possible.

Mr. Carney. It's difficult to go back to that incident. I know that no one today will be in a position to speculate, or should be in a position. I don't even think we should ask any of the witnesses today as to what they would speculate the reason was. It is somewhat premature.

But over international waters, particularly in that area, are there vast distances before they would be picked up by some international ground group that has the responsibility of air separation and location of aircraft?

Mr. Reynard. You can have quite long distances before you are picked up by some ground facility. But if, in fact, you have managed your internal airborne system properly, and if you are monitoring that system accurately, you should not get yourself into a position where you are that far off course.

Mr. Carney. Do you have cooperation with the military? I would imagine that they have some sophisticated equipment to keep track of airspace, particularly in that area. Do you have cooperation of the military when someone might deviate off course? Do they——

Mr. Reynard. We have a reciprocal agreement with the military to provide us with reports involving some type of problem where there is a civil interface. If the problem is strictly a military problem, then we don't get that report. If, in fact, a military aircraft was relying, for instance, on a civilian navigation aid and had some problem, we would hear about that.

Mr. Carney. I appreciate that. I think, though—[TV monitor noise.]

This is the Science and Technology Committee room.

Mr. **Reynard**. Is that what they refer to as the "cutting edge"? [Laughter.]

Mr. **Carney**. What I was trying to get to is, if a military operation, a military program designed to track planes in airspace, were to pick up a civil plane or a commercial plane off course, would they relay that message to a civilian group that could contact the plane? Would they contact the plane directly? Would they try to ascertain why they would see a plane so far off course?

Mr. **Reynard**. I, frankly, don't know the answer to that. I'm simply not aware of what the procedures are in that kind of circumstance.

Mr. **Carney**. Do you see anything that can be done to improve navigation, both domestically and internationally?

Mr. **Reynard**. Well, the data would certainly indicate that you can never train too much, and you can never accentuate the fact that ultimately it is the crew's responsibility to make sure the thing works right. So consequently, what I would say, if there is to be an emphasis, it would go in two directions. No. 1, to enhance and increase the training with regard to the crew's awareness of the fact that these situations do exist. The problem is, we have such an active system, and it goes so well so often, that you tend to forget the fact that you can have problems, and when they do occur, only a small percentage of people ever hear about them. So you don't have this widespread "hangar flying," if you will, with regard to what can go wrong.

So in my mind, from my world, I would say to enhance the education of the flight crews with regard to the possible failures of the navigation system and, more importantly, the possible failures of the flight crew, and to maintain an environment where the flight crews feel free to discuss what their errors have been so it doesn't get cooped up and nobody learns about it.

Mr. **Carney**. That would—the programs that you talk of would be in the best interest of the airlines, and I am sure they pursue those types of programs——

Mr. **Reynard**. Yes, sir.

Mr. **Carney**. It's just a matter of how many hours you can have your pilots in the training programs, and there are other parts of the training program that probably are of greater concern to pilots and to airliners from the standpoint of emergencies, mechanical failures, landings, takeoffs, that type of thing. This might focus some attention to that, hopefully it would.

But I would find it rather ironic that a 747 is blown out of the sky by a heat-seeking missile and then the Federal Aviation Administration would go out and spend millions of dollars to correct the problem. I mean, I don't see that to be the problem.

Mr. **Reynard**. No, I certainly agree with you.

Mr. **Carney**. It's something that you might want to say is a discipline on those who are responsible in the cockpit. And I wouldn't want anyone to think that any member up here believes that our airline pilots are complacent. That's just a very difficult thing, when you have such high technology in the cockpit, that is so reliable, to continue to remind yourself to go back and check, check,

check. After you check it a thousand times and find it to be accurate, you might decide to slip once or twice.

Mr. REYNARD. That's right.

Mr. CARNEY. You might be preoccupied with many things that are much more important in that cabin at the time.

Mr. REYNARD. The air carriers and groups like the Air Line Pilots Association and the Allied Pilots Association have all come up with ways of addressing the issue of complacency, particularly in the advanced generation aircraft. You know as the aircraft become more and more sophisticated, and the automated devices are doing more, you have to be somewhat creative to overcome the complacency problem, simply because things are so doggone reliable. Those groups—the pilot groups and the management groups—are working actively to do that. But you still—it's like anything else, when something works so well, you've just got to impress upon people the fact that this really can happen. It doesn't happen very often, but when it does happen, you've got to be prepared for it.

Mr. CARNEY. It's unfortunate that the reminders of these things happening are so devastating in many cases.

Mr. Chairman, that's all the questions I have of the witness. I would just like to thank him for his testimony. It was very informative.

Mr. GLICKMAN. Thank you.

Mr. Gore?

Mr. GORE. Thank you, Mr. Chairman.

Mr. Reynard, I would like to focus in on the particular system in use by the KAL flight 007 airplane. You mentioned 22,000 incidents and 454 navigation-related errors; is that 954 navigation-related errors?

Mr. REYNARD. Right.

Mr. GORE. How many of those involved the same system used by flight 7?

Mr. REYNARD. Approximately 21 events.

Mr. GORE. Over a 5-year period?

Mr. REYNARD. Yes, sir.

Mr. GORE. So in the last 5 years there have been 21 navigational errors, in one case leading to a flightpath that was 250 miles off course——

Mr. REYNARD. Yes, sir.

Mr. GORE [continuing]. Related to the use of this INS system.

Now, am I correct in assuming that this system is limited in that it can only hold nine checkpoints simultaneously?

Mr. REYNARD. Well, there are really only 10 positions into which you can put waypoints. But once you've passed a waypoint——

Mr. GORE. Yes.

Mr. REYNARD [continuing]. You can reprogram it.

Mr. GORE. That's correct.

Mr. REYNARD. But theoretically, you can just keep a cycle going.

Mr. GORE. But international flights commonly require 12 check points?

Mr. REYNARD. I'm not familiar with that figure; no, sir.

Mr. GORE. I am told that's the case. And as a result, the crew is required to reprogram the INS computers in flight to add the additional check points that could not be held at the beginning of the flight; is that—well, we can——

Mr. REYNARD. If, in fact, they were required to have 12, that would be correct. It's not a particularly threatening procedure and it certainly isn't something that you would necessarily have a higher chance of mismanagement than simply programing the first 10 on the ground. As long as you've got the numbers and you put the right numbers in; OK.

Mr. GORE. Well, is it true that the other two INS computers can be programed directly by the first, so that if you put the information in one of them, it can automatically be put into the other two?

Mr. REYNARD. I have heard that there are two types of systems, one where the management purposely keeps the systems independent, the reason being that if you have an error in one you don't want to duplicate it in the others by simply repeating the program in the other two automatically.

Conversely, I've heard that there are systems whereby the various INS's can, in fact, if you will, talk to each other and relay the information. The basis for that is that some management and operational people view INS's, particularly when there are three, as kind of a voting system as a secondary function. So that if you have one that seems to be off, you essentially take a vote, and if two of them are nearly in agreement and the third one is not, then it's a 2-to-1 majority and the two win.

Now, to be quite frank with you, my basic impression is that most systems are independent.

Mr. GORE. Well, we'll explore that with further witnesses.

Now, have you explored the possibility of a simple transposition of coordinates? There's been speculation that, for example, one of the check points, NOCA, near Hokkaido, has as support of its coordinates 42 degrees, 23 minutes, 3 seconds north, and 147 degrees, 28 minutes, 8 seconds east, and if those had been transported to 47 degrees north and 142 degrees east, instead of the other way around, just two digits transposed, then that transposition would have accounted for the route that the airliner took.

Have you explored that possibility?

Mr. REYNARD. Well, in the first place, we haven't—I haven't tried to go into any kind of analysis of what the Korean Air Lines flight might have done simply because we work from the basis of the data that we have telling us about the problems. We have, in fact, looked at the data, and there are instances where a transposition of numbers have, in fact, caused problems. It's not——

Mr. GORE. How many times—how many of these 21 episodes in the last 5 years have been caused by a transposition of numbers?

Mr. REYNARD. If my memory serves me right, it was about four.

Mr. GORE. So four times in the last 5 years planes have strayed off course using the same system that flight 007 used, because the crew accidentally put in the wrong numbers; is that correct?

Mr. REYNARD. That's the number of reports we've had turned in to us; yes, sir. Now, the thing is, in those four instances, the crew caught it, simply because there is a display on the panel that gives you the numbers. And if you cross-check it properly, you have got the data here and you have got the data in the panel, and if the numbers don't agree, then, with the exception of the base site—if you've screwed up the coordinates at the point from which you took off, then you've got to go back and start all over again, essentially. But if one of the way point coordinates is wrong, you can, in fact, if your base site is correct, you can reprogram it. This is how it has emerged as having been solved, because somebody in the crew did what they were supposed to do and said, "Look at this; we've got the numbers reversed."

Mr. GORE. Now, let's look at the rest of these 21 episodes involving the INS system. And, incidentally, INS is this self-contained system, it has gyroscopes, it accurately measures the thrust and any movement in the plane; it's essentially self-contained, and that distinguishes it from earlier navigation systems that relied on plotting points against known locations or stars, et cetera.

Now, you say 4 of those 21 instances involved the transposition of numbers entered by the crew. What about the other 17?

Mr. REYNARD. You have a series of situations, the one I mentioned before, where perhaps you're on the INS mode navigating, you want to go around weather, so you put it on a heading mode or a manual mode, and you simply just don't switch it back, just forget to do that.

The aircraft being moved. If, in fact, the aircraft is moved prior to the time that the way points are put in, then if it's sitting in San Francisco and one of the little accelerometers inside the INS feels a movement—let's say the tug moves it from gate 1 to gate 2—while the thing is getting up speed, you don't know where it's thinking it is. If you then go ahead and put way points in, you may be starting from San Francisco but the machine may think it's in St. Louis, so you don't know what you're going to end up with. That's why it's absolutely critical that you follow the procedures prescribed by the operations manual.

Mr. GORE. Would you say that even though the—well, you don't get all the incidents reported. People call you up anonymously, they give you information, you get information on domestic flights, very few incidents involving international flights are involved. But you get a lot of reports, and relatively few of them have involved this particular system. But 21 of these episodes in 5 years' time is significant.

I am wondering whether or not you would agree with me, that this many episodes involving this system would mean that it is susceptible to human error without additional measures being taken to insure that the pilots and crew operate the system exactly as it's supposed to be operated.

Mr. REYNARD. Well, what I have to do every time I look at a set of numbers like that is to remind myself of the fact that all we hear about are the things that go wrong. What we don't hear about are the thousands and literally millions of times that an aircraft takes off, using that very system, and it works perfectly. So, consequently, I'm not sure that 21 reports out of the 22,500 that we have in our data base, which represents a percentage of a much greater universe, if you will, represents that much of a problem, especially when it's coupled with the fact that this type of problem represents a situation that's awfully hard to hide from your own management or from the FAA, if that is pertinent. In the sense that if you're off course and if you take off from Honolulu, and you take off and you have to turn around and go back to reprogram the INS, somebody's going to notice. So consequently, the airline management is going to say, "OK, what's the problem here?" Consequently, you have a secondary back-up in the sense that these are the type of problems, particularly the human error problems, where awareness is relatively high in the few instances when it does take place. So consequently, it's addressable.

Mr. GORE. Well, of course, if it, indeed, turns out that this was the cause of Flight 007 straying off course, it becomes quite significant, indeed, and must be corrected.

I just want to close by underscoring a statement you made in your opening remarks, which I thought was quite perceptive, and that is that this system, as well as other highly computerized systems, seemed to reverse the respective roles of man and machine, assigning to each a role that it is uniquely not best suited to perform. Specifically, here you have a system that requires decisions, in effect, or course corrections by the machine and a routine monitoring function by the human beings. That's not what each does best. And in designing these systems, a great deal of attention has to be paid to the relationship between man and machine and the routine which takes places in cockpits.

Again, I think it is very timely and important for the subcommittee to undertake this exploration, and I, for one, appreciate your participation in it.

Thank you, Mr. Chairman.

Mr. GLICKMAN. Thank you, Mr. Gore.

Mr. McCandless?

Mr. MCCANDLESS. Thank you, Mr. Chairman.

Mr. Reynard, in the process of establishing and evaluating these reports establishing an information data bank, do you do an analysis of the activities around which the error took place at the time that it happened, the one that was reported to you?

Mr. REYNARD. Oh, very definitely. The major thrust of our research is into the interactions of the human to a large extent. The data, of course, is usable in many varieties, but our particular interest within the life sciences director out at Ames Research Center is in this human factors issue. For instance, there is a function of what we call interpersonal relationships. Is it possible to look at a given set of incidents and be able to discern that the relationship between the crew members, particularly the captain and the first officer, perhaps led to that problem. If you've got a crew that only communicates when they absolutely have to, sometimes you have a less efficient environment than you have in the situation where people are free to discuss things back and forth.

You have also got the issue of distractions, in the sense that an incident can happen and the incident can be a symptom of a greater problem, and that greater problem might be a distraction within the cockpit. So consequently we do try and find out.

Incidents, like accidents, are usually the result of a series of circumstances. Very seldom does one thing cause an end result. It is usually a build up of situations.

Mr. MCCANDLESS. In the process of analyzing this material and coming up with conclusions, do you make specific recommendations to the FAA who you're on contract to provide this information for?

Mr. **Reynard**. In fact, we have a system to alert the FAA to a situation that may need further investigation. They're in a much better position to investigate the issue more fully than we are. We can provide basic data and we can also provide essentially a pointer, saying this looks like it's a fertile field to look at. In fact, in the last several years, the FAA has taken essentially a leadership role in the sense of reviewing the data to see what problems are there so that they can address them first off.

Mr. **McCandless**. In your remarks you talked about the complacency in the process of navigation because of the number of flights and the accuracy of the instruments and the human animal and his wanting to take the route of least resistance.

I understand—and please correct me if my understanding is incorrect—that there is no specific FAA policy that deals with the checking or cross-checking or doublechecking within the crew itself of navigational systems, that each airline has its own mode of operation. Is that a correct assumption?

Mr. **Reynard**. I would have to defer to the witness from the FAA. I simply don't know the answer to that question.

Mr. **McCandless**. In the process of your investigation, have you found anything in the way of the cockpit design, the position of the navigational system, such seemingly inconsequential things as the lighting system and how it makes the instrumentation visible for purposes of punching, of any consideration in these areas where you have found errors?

Mr. **Reynard**. Well, the most obvious ones that strikes my mind is the standardization of equipment and the placement of switches, dials, et cetera. If you've got a fleet of, say, 15 aircraft, and of those 15 aircraft 5 have got one type of equipment and 5 have got another and 5 have yet a third, and you have the crews switch off between aircraft, you're simply creating a situation that's prone to error because you have to stop and think about which equipment it is on which aircraft and what the position of the switches and knobs and things should be. So consequently it's a basic design function.

Mr. **McCandless**. If I'm an airline and I have, say—I'm going to use hypotheticals—I have 10 pieces of equipment of the same origin, same type of level, could it—you're saying to me the various types of navigational equipment could vary within those 10 planes, if they were all of the same make?

Mr. **Reynard**. Very definitely. If you were to begin a process of purchasing aircraft and you didn't purchase them all in a block under specific specifications to your purchase—let's say, for instance, you were buying used aircraft—and you happened to buy 10 aircraft, and 3 of them came from 1 company and 3 of them came from another and 4 of them came from yet another, the odds are pretty high that you're not going to have an absolutely identical system across the board in all 10 aircraft.

Mr. **McCandless**. Even though they were purchased, say, within a reasonable period of time, within a 2-year period or something like that?

Mr. **Reynard**. Aircraft are generally manufactured to the original purchaser's specification, and if the original purchaser of aircrafts 2, 3, and 4 wasn't the same as aircrafts 8, 9, and 10, the chances are there will be some type of deviation from a standardized presentation. This is true not only with regard to navigational equipment, but also anything in the cockpit that relies on equipment placement.

Mr. **McCandless**. Have you, in any of your investigations, found any kind of a third influence, instrumentation from other than the aircraft, signals being given by some piece of electronic equipment, as being any kind of a factor that would compromise the instrumentation as far as the navigation system is concerned?

Mr. **Reynard**. It certainly is not an uncommon event with regard to nondirectional beacons—for instance, radio stations, where you have possible interference from other radio stations, or severe thunderstorms, things like that.

There also can be situations, particularly in communications, more so than navigation, where you will have interference on the frequencies. But as a rule, that has not been a problem with navigation equipment, with the exception of the ADF.

Mr. **McCandless**. Would you say it would be possible to intentionally compromise such a system, based upon your knowledge and investigation in these various numbers——

Mr. **Reynard**. We certainly have no evidence of somebody doing it intentionally. The general situation is that you have—for instance, you have a radio communications frequency that may be being interfered with by a radio station in proximity to the transmitter site for the air communications facility. It is simply a matter of antenna placement, shielding, et cetera. But as far as intentional activities, I couldn't even address that issue. We certainly have no evidence of it.

Mr. **McCandless**. Thank you, Mr. Reynard.

Thank you, Mr. Chairman.

Mr. **Glickman**. Thank you.

Mr. Andrews.

Mr. **Andrews**. Thank you, Mr. Chairman.

You mentioned earlier in your testimony about the number of other errors that occurred, most of which occurred over land. I wonder if you would relate to us, in general, what were some of the causes for those errors.

Mr. **Reynard**. Well, the examples could range anywhere from using a wrong chart. If you use an old chart and the frequencies have changed, you're asking for trouble.

You've got a situation where, let's say, for instance, again in the realm of the chart, you look at a chart and you see that a radial off of it, a VOR, is, say, 42 degrees, and close by it is another air-way that perhaps has a radial of 32 degrees. If you aren't discerning—and I'm not saying that this is a common event because it's not—but I can recall a report where the crew read the wrong radial number, put that radial in, and was steaming off in the direction of the 32 degree radial as opposed to the 42 degree radial, simply a matter of misinterpreting a chart.

You have got a situation where, in fact, you may—if you have a multiplicity of navigational devices in the cockpit, in the process of switching between the various devices you may not get back into the mode that you wanted to be in and, in fact, you would be navigating on an auto system using a navigation aid that you weren't intending to use, things like that.

Mr. **Andrews.** It seems like, in hearing your testimony, we keep coming back to complacency on the part of the crew in many of these instances.

How can, and how many different ways are there multiple cross-checking abilities on an aircraft, and specifically, if you know, on 007?

Mr. **Reynard.** Well, if you took a typical INS operation—let's say you took the North Atlantic route, you're leaving from New York and you're going to go to London—you have multiple opportunities to—first of all you check to make sure you put the correct way points in on the ground. You go back and you double check the numbers. Then as you go, you can ask the INS to show what it's showing in terms of coordinates, even as a cross-check between its own way points. You can use VOR navigation aids to confirm your route of travel.

You can use geographic references. I mean, if you are on a certain INS route and that route should take you over Martha's Vineyard, and you get to the point where you're supposed to be over Martha's Vineyard and you're not there, you know something's wrong. So consequently, you've got a multitude of ways of cross-checking, and it is usually the function of the crew to utilize as many as possible, certainly at the beginning of the flight, to make sure that they have done the right thing and hopefully thereafter with every reasonable opportunity.

Mr. **Andrews.** Do most airlines have set procedures for requiring cross-checking at certain points in a flight?

Mr. **Reynard.** Most operations manuals will require the crew to utilize specific cross-check procedures, verifying all way points, using cross-checks with other devices when they're possible, et cetera.

The economic considerations alone are worth making sure that you are where you're supposed to be, notwithstanding the fact that the pride of the crew has said that, you know, "we're going to fly this thing the way we're supposed to."

Mr. **Andrews.** Do you know whether or not the crew of 007 was required to make those cross-checkings?

Mr. **Reynard.** I don't know what Korean Air Lines procedures are; no, sir.

Mr. **Andrews.** Do you know, from reviewing the transcript that you supplied us with this morning, whether or not any of those cross-checks were made and reported?

Mr. **Reynard.** I think you may be confusing me with somebody else.

Mr. **Andrews.** Excuse me. We've got a transcript today of communications from 007 and I'm curious—do you know from your review of the transcript whether or not any cross-checks were made.

Mr. **Reynard.** I haven't seen the document you're referencing.

Mr. **Andrews.** All right.

Is there requirements, when a cross-check is made by a crew, that that be reported back to the ground or communicated back in some way so controllers on the ground can also doublecheck or be reassured that those cross-checks were made?

Mr. **Reynard.** Oh, it's entirely conceivable. We have had for a number of years a series of reporting points that if, in fact, the air traffic control people or the company want to know where the aircraft is, they can ask or establish that requirement as part of the operations function.

Mr. **Andrews.** You mean each airline does that?

Mr. **Reynard.** Well, they can. An ATC can say report—what was the one we crossed yesterday, Crazy Lady, out in the Middle West, because it's a reporting point. It's a navigation aid. You essentially want to know when the aircraft gets there to verify his position, perhaps verify the ATC readout, whatever the purpose would be. It can be done and it usually is done on request.

Mr. **Andrews.** Thank you, Mr. Chairman.

Mr. **Glickman.** Thank you.

I just have one question. One of the cross-checks frequently is looking down——

Mr. **Reynard.** That's correct.

Mr. **Glickman.** Do you know what the weather was at the time of the KAL crash? Do you have——

Mr. **Reynard.** No, sir.

Mr. **Glickman.** You do not know that independently.

One would assume a pilot could look down, though, and see if there were any lights visibly, even at night, if he could see any evidence of——

Mr. **Reynard.** I have been told that there are, in addition to simply looking out the window, you can also direct the airborne radar down and detect land mass configurations, and if you're familiar with that configuration, you can say OK, this must be such and such.

Mr. **Glickman.** OK. Of course, we don't know if that was done in this case?

Mr. **Reynard.** I certainly don't have any idea.

Mr. **Glickman.** OK. Mr. Carney had one more question.

Mr. **Carney.** Thank you, Mr. Chairman. I actually have two, and I'll do it as quickly as possible. One, a hypothetical question.

When we were using the most rudimentary navigational equipment in aircraft, the pilot's attention was much greater to the positioning of the plane. Their proficiency, I would suspect, even improved with the advent of some new navigational equipment, the new technologies.

Have we come to a point where there is so much high technology in the cockpit that the proficiency of the crew is diminished from that cockpit having so much material available, so much data available, so much—well, data I guess is the best word to use. Has that perhaps had a negative impact? Is there too much in the cockpits now?

Mr. **Reynard.** Well, it's certainly possible, but it doesn't have to happen. If you structure the cockpit procedures properly and impress upon the crews the importance of it—and most crews recognize the importance of it—that situation won't happen.

It goes back to the very basic example that I cited in my opening statement, that in an age of increased technology you have to be aware of the fact that the roles are reversing for these two elements, the machine and the human. And what you have to do is to find new human factors engineering, if you will, to keep these people to the point where they are exhibiting the type of awareness they should. It's a combination of impressing the people with the awareness of the need to do this and also presenting the data in such a way that it is easily understandable and can be used effectively.

Mr. **Carney**. My final question is, my understanding that with the completion of the GPS, the global positioning satellite system, when the 18 satellites are up there, they will be able to identify a plane's location within a distance of 300 feet on the entire globe.

Would you say that this would prevent these types of incidents from occurring again in international areas where there are fewer radio check points and fewer navigational aids?

Mr. **Reynard**. It will certainly contribute to better pinpointing where the aircraft is, not only from the standpoint of the flight crew, but from an outside reference that perhaps could bring their attention to it.

Mr. **Carney**. That's the point I was going to make, that when we have the global positioning satellites in place, ground communications would pick up a strayed aircraft and they will have an ability to shake the thought process in the cockpit to check just where the plane is. So that would be a——

Mr. **Reynard**. I'm not that familiar with the technology, but I would assume that would be a side benefit of that system, yes.

Mr. **Carney**. So what I guess I'm trying to build a case for is that we're doing everything humanly possible right now and the system is pretty good; it needs some new advances, particularly over the waters, because of the large area that you have to cover with fewer navigational aids. The global positioning satellites will fill that gap. After that, I can't think of too much more you can do to prevent this from happening.

Mr. **Reynard**. Just keep reminding the crews of the need for awareness.

Mr. **Carney**. Thank you, Mr. Chairman.

Mr. **Glickman**. Thank you, Mr. Reynard, for your testimony. You have been a very informative witness.

We are going to deviate from our schedule a bit. I understand one of the witnesses has to leave by 12:15, Capt. William Frisbie, regional chief pilot, Pacific, Pan American World Airways. I think that, given the fact that you have to leave at 12:15, and this gentleman may have extensive flying experience in that area, it may be worthwhile to take him now.

STATEMENT OF CAPT. WILLIAM FRISBIE, REGIONAL CHIEF PILOT, PACIFIC, PAN AMERICAN WORLD AIRWAYS, INC.

Captain **Frisbie**. Thank you, Mr. Chairman. I do understand my priorities and my schedule isn't that important.

Mr. **Glickman**. If you have to fly somebody somewhere, we want somebody with your experience to be up there.

Captain **Frisbie**. But I certainly appreciate the opportunity to comment before you today. I understand that you're looking for comments from me as a user of the North Pacific composite route system for air navigation, and perhaps some of my comments could answer some of the questions that have already been posed and save a little time in that manner.

Mr. **Glickman**. OK. You have no prepared statement, then? You're going to be just——

Captain **Frisbie**. Sir, I have a briefly prepared statement. I wrote something coming down this morning. If I can read it, I think it might preempt some of the questions that would unfold.

Mr. **Glickman**. That's fine. Thank you.

Captain **Frisbie**. By way of introduction, my name is Bill Frisbie. I am the regional chief pilot, Pacific, for Pan American World Airways, and I am based in San Francisco, Calif. In this position, my responsibility includes Pan Am's flying operations for the areas between India, the Western United States, together with the China area and the polar routes to London, Great Britain.

I should mention to you that I am coming to you cold, so to speak, because I went on vacation on September 1 and I only have brief reports of the tragedies that occurred on that date. Perhaps in some way that's just as well because what I have to say has not been colored by anything I have read or heard. In fact, I was at a fishing trip in northern Canada when they reached me over the weekend and asked me to be here this morning. But it's back to work after today.

Mr. **Carney**. Were they biting? [Laughter.]

Captain **Frisbie**. Yes, and they were delicious. [Laughter.]

The North Pacific composite route system came into existence about a year-and-a-half ago. It's a heavily traveled route, especially during the peak periods, and this heavy flow too often causes air traffic control delays to the user air carriers. Computer flight planning systems of the various air lines routinely select the same particular route or track and it is not uncommon to encounter very adverse wind components if we have to deviate from this optimum track. Even a deviation of 1 or 2 degrees in latitude, 60 or 120 miles can make a big difference in flying time and the fuel consumption.

Recently, I think it was on September 2, changes were made in the Norpac system. These changes eliminated red 20, the northernmost track. They also modified the entry procedures into this composite track system. Even before these changes, which reduced the capacity of the system, even before these changes were made, the Norpac system was inadequate in providing air traffic control service through the Anchorage flight information region.

During peak periods, some flights are delayed for air traffic control clearance. Probably 40 percent of the flights departing at given times are delayed because of the lack of the ability of the system to provide the service. For example, the San Francisco/Tokyo flight probably is delayed nearly 50 percent of the time.

Those recent modifications to this Norpac system have caused additional problems and near-term changes must be made before the winter wind patterns develop. Those winter wind patterns require or plan the aircraft to fly in the northernmost tracks where the adverse headwinds are not quite so strong. In the longer term, a whole new navigation system is needed.

The present system of over-ocean or onboard navigation is accurate, but can be vulnerable to human error, as we have heard about this morning. Inertial navigation systems depend on accurate input or en route navigation accuracy; that is, if you improperly set up or program an inertial navigation system, it will warn you in case of error. They compare each other and they are set up individually. If someone has made a mistake in the programing, a red warning light comes on and it tells you and you never leave the ground.

However, en route, there is no warning provided for human input errors, such as transposing the coordinates—and I think it was Mr. Gore earlier that heard speculation that coordinates could have been transposed which would have put the airplane where it ultimately was destroyed. To preclude or reduce this chance of error, at Pan Am we have established and trained our pilots in the use of backup or cross-check procedures. Let me cover them briefly.

When flying the North Pacific route, one pilots inputs the INS computers with the coordinates of the various way points, and then he assigns a number on the flight plan to each of those nine way points. And then, when we use those nine, and we pass them, we put nine more in if we need that many. One pilot puts them all in and numbers them. Independently, and not simultaneously, the other pilot rechecks all of those positions, and to indicate he has rechecked them all, he then puts a circle around them. This is double checking the initial input of the computers.

Second, once that's done, and before we leave the ground, we do a distance check. We accomplish this by asking the computer what it thinks the distance is between each of the nine way points—that is, one to two, two to three, et cetera. And our computer flight plan, independently programed, has those distances displayed on that. One by one, as we check those distances—because if we transposed a mistake in those positions, we would not have had a warning, as I mentioned earlier. But once we check these distances, if there was a mistake, we would be alerted because the mileage wouldn't be right when we asked the computer what the distances are. We probably put this into effect, oh, 5 or 6 years ago, and it has proved to be very, very helpful in avoiding these kind of human error inputs.

Then later, approaching each particular way point as we are flying on a given route, the INS systems have a yellow warning light which comes on, and that's usually about 2 minutes before you get to the position. At that time our pilots are required to write down the position that is displayed on the INS navigation system; that is, the latitude and the longitude coordinates. They write that right on the flight plan, right adjacent to the coordinates that are spelled out in the flight plan, and check it for accuracy and for error. At the same time, and before proceeding beyond the way point, they then are required to recheck a third time the coordinates of the next succeeding way point that we're flying to. And when they do that, they now draw a line through the circle that was drawn after the first pilot programed them, so this is almost a fourth check that those coordinates are correct for the next position.

And then, having done that, they look at the distance to the next position on the flight plan, be it 221 or 610 miles, and say the distance to the next check point will be—and when the autopilot makes the change over, they check the distance and then they draw another line through the distance check. So that has now been X'd out and it's behind us. So that distance check that is done is very, very helpful again, for the same reason it was when we did it on the ground. An error that occurred later will be evident because the distance won't be the same to the improper checkpoint.

Any time we fly using INS navigation at Pan Am, we display on our flight instrument panel—on what we call a horizon situation indicator or an HSI—we display INS navigation instrument information, so that if the airplane deviates from course—and earlier Mr. Reynard mentioned that that can happen in deviating around weather—it actually shows us both the angular and the distance display from the desired track and we can look at it right on our instrument panel without even looking at the INS presentation.

The other thing that we do on North Pacific tracks is we require the continuous use of onboard aircraft radar to monitor the various land masses that are to the north of our track. This, again, has been established in our procedures and required for years and years.

These procedures that I have just outlined are thoroughly covered in our training. They are reviewed annually during the captain's annual proficiency line checks as well. In my opinion, these present INS nav systems are capable of very, very accurate navigation, similar to that which has put our people on the Moon. In order—Well, let me read my notes here because I forgot what I was going to say.

The procedures I have just outlined guarantee the precise aircraft navigation that the INS system is capable of, so using these procedures, you can guarantee the accuracy that the system has inherently in it.

Now, we have talked about human error. I guess as long as there's people, there will be human errors, and we're looking at ways to nullify or reduce that error. These procedures I have outlined here have effectively done that for us at Pan American. But I think our industry needs new communication and navigation systems using the satellites, the GPS. Long-range, high-frequency communications are poor and they have improved only slightly in my 28 years of airline experience. The present domestic, if you will, VHF communication and navigation systems are only capable of line-of-sight distances, and that, of course, varies with your altitude. But 220 or 230 miles is just about as far as a navigation signal is useful at this point when it's generated on the ground. We need a global positioning system which would provide this coverage everywhere, and I hope that the FAA's proposed improvement programs, using the ADAP funds, won't be delayed in generating such a program.

Obviously, that would be the backup that we would have, just as we have when flying across the United States. We use INS flying across this country now, but we use the land-based navigational signals to check it and to recheck it. We would like to have that capability everywhere in the world, and it shouldn't be too far away.

I recommend that the system be restored, that is, the North Pacific composite track system be restored, by promptly reopening red 20 and removing the track entry restrictions that were imposed on September 2.

I have two specific suggestions that are offered to enhance safety for the users. One is that flying along that track we have many position reports which are not compulsory. The pilot reports only compulsory reporting points, and yet there are several that he isn't required to report. I think when we design a track system in a sensitive area that we should be required to report all of those position reports, because all of the doublecheck disciplines that I talked to you earlier about would occur more often. That's obvious.

The other thing that I think we could do is modify the reporting positions along this track system to even numbers of latitude and longitude, where that's possible. This would reduce the likelihood for transposing numbers.

One of the committee members discussed the possibility of the transposition—I think it was Mr. Gore, again, earlier. Let me give you another example.

On red 20—this is the route the KAL 007 was flying—one of the positions is called NIPPI. NIPPI's latitude and longitude coordinates are north 41 41.9, east 159 19.3, a lot of numbers for somebody to have to type in late in a flight, and for someone else to have to check. If we changed those numbers of NIPPI and just slightly altered the physical location of the track, we could say north 50 degrees, east 160 degrees. We wouldn't make transposition errors with simple numbers like that. This would result in very, very little track location change. It would require moving the boundary of the air traffic control centers to a north-south orientation instead of a northwest-southeast orientation. It should be easy to do.

There are other air routes around the world where air carriers operate near unfriendly borders. Red 85, around Vietnam, is just one example where the track is planned to operate 20 miles from hostile land, much closer than it is in red 20. It is, of course, prudent to thoroughly review all factors after a situation such as the loss of Korean flight 7. However, we must not close each highway, airport or airway that presents us with a tragedy.

I thank you for the opportunity to comment, and I would be pleased to attempt to answer any questions you may have.

Mr. GLICKMAN. Thank you for some excellent testimony. From your experience as a user of the system, I think you probably have more valuable words than anybody else. I am going to have a series of questions which you may or may not feel competent to answer, because you may not know all the facts regarding the KAL situation, but I think they need to be asked in order to try to prevent the thing from happening again.

Based upon your experience—and you have flown red 20 before?

Captain FRISBIE. Yes, I have. I was involved in discussions leading to the organization of that track system. I fly the route frequently myself.

Mr. **Glickman**. OK. Based on your experience of flying the route, what do you think caused the plane to veer off course?

Captain **Frisbie**. Well, I am reluctant, of course, for reasons mentioned this morning, to point a finger or speculate on something——

Mr. **Glickman**. What could have caused the plane——

Captain **Frisbie**. Human error certainly could have caused this kind of an incident, or a navigational mistake.

Mr. **Glickman**. Human error in terms of——

Captain **Frisbie**. Human error in terms of inputting the computers and the lack of the necessary disciplines to followup and provide the double checking and rechecking when using this type of intertial navigation system.

Mr. **Glickman**. Now, let me go back for a moment to try to figure out the various points that you're responsible for putting the numbers into the computer. Let's say you're leaving Anchorage, you're flying red 20, and there, of course, you have to plug in your numbers into your INS system. You have—and you would plug them in, as you talked about, in an independent fashion, almost like you're checking on each other, so to speak. And then—By the way, do your computers talk to each other? Do you plug in each of the INS systems independently?

Captain **Frisbie**. Ours are like most others, I believe, and that is that they must be independently programed for initial accuracy. However, they can be programed to talk to each other for installing the subsequent positions or way points.

Mr. **Glickman**. Do you think that's a satisfactory system?

Captain **Frisbie**. Yes; I think it is. I think it actually enhances safety because there are so many of those numbers to check and look at, that by having one person do all nine positions and at the same time put them in three different units, saves time and allows him to monitor the progress of the airplane, handle communications, and watch the other factors of operating the airplane.

Mr. **Glickman**. OK. So once you plug in your numbers, and you've taken off from Anchorage—I'm trying to figure out how you change your numbers, your coordinates, because you're obviously flying to a variety of checkpoints. Are you constantly changing your coordinates as you're moving from one compulsory point to another compulsory point?

Captain **Frisbie**. No, sir, we're not constantly doing that, but we do load nine way points and typically, on an international sector, they will be for positions that may be 45 minutes to 1 hour and 10 or 15 minutes apart. So we are looking at being able to fly long, long distances without the requirement to do this programing.

What we do then, before using the last way point in the system, is we change the way points at the positions we have already flown by and we will do a half a dozen of those perhaps at one time during a quiet portion in the middle of a longer leg, when we have an hour or so between position reports, when all these disciplines I spoke of at the various positions are out of the way. When our position reports have been made, then one pilot will do them, the other pilot will monitor the flying of the airplane—it's probably on autopilot. When he has completed putting in these new positions, then he says to the other pilot, "OK, I have the airplane. You watch the airplane. I will take my separate charts and I will independently check all of those way points." We independently check all nine positions in all three computers.

Mr. **Glickman**. OK. Now, when you fly over red 20, what's your distance from the Soviet airspace supposed to be?

Captain **Frisbie**. The nearest land mass, if my recollection serves me correctly, is about 52 miles, a little island northwest of Shemia on the western extremity of the Aleutain Chain, and Kamchatka Peninsula is somewhat farther away, but our radar goes to 300 miles so we can easily see this. And later, in the Kuril area, I think the track gets as close as about 52 miles from some of the small islands right in that area.

Mr. **Glickman**. Now, do you keep your radar on all the time once you are getting near Soviet airspace when you're flying red 20?

Captain **Frisbie**. Yes, sir, we do. We require that it be on board, that it be operating, and that it be utilized by the crew.

Mr. **Glickman**. Is the radar sophisticated enough to delineate land masses?

Captain **Frisbie**. Yes, sir, it is. Even when outside forces such as weather are around, we can still easily distinguish the land masses.

Mr. **Glickman**. So an airplane flying that route with its radar on, even if it were deviating—even if the inputs were wrong—if he had his radar on, he would have been able to see that he was flying closer to a land mass than he should have been?

Captain **Frisbie**. Yes, sir, if the radar was on and they were alert to this, they should have easily known. They or any carrier in that area should have easily known that it is where it should not be.

Mr. **Glickman**. To your knowledge, do all carriers that fly red 20, or any of those routes, keep their ground radar on?

Captain **Frisbie**. No, sir, I am not sure of other carriers' procedures.

There is one thing I may have missed that we do at Pan Am as well. When we're flying in an area requiring specialized navigation, we use a chart such as the one I have in my hand. We require that the crew members draw a line from all of the area that is covered by the inertial navigation. I have half a dozen copies, if you would like to have them.

Mr. **Glickman**. Yes.

Captain **Frisbie**. And when we pass each way point, having done all of those things that we did before in the way of cross-checks, one of the pilots looks at the INS position indication, which is constantly changing, and he writes down the latitude and the longitude displayed by the INS computer and then he plots that on the chart, noting the time, noting the numbers, and putting a triangle around it as a fix, and checks that to make sure that that position is actually on track.

Mr. **Glickman**. Let me ask you this question. There was some discussion the radio—you talked about the deficiencies of lateral communications, radios, and your case for moving ahead with the GPS or satellite system. There was some discussion that the airplane's radios were not working as well as they should and they had to go on alternative radio systems, standbys or—I'm not sure exactly what they were called. I have seen some of the transcripts between ground controllers in the Alaskan Aleutian chains to this effect.

Could there be a general computer failure, an electronic failure in the aircraft, that could have affected both the navigation systems, the radio, and perhaps the ground radar as well?

Captain **Frisbie**. It's—in my opinion, we could have a problem that would affect the ability to communicate, because the HF radio system, which hasn't been changed much in 30 years, is subject to outside factors which can cause very poor HF communications. However, to knock out all of the INS systems, which are independent—they have their independent electrical source—in my opinion is almost inconceivable.

Mr. **Glickman**. OK. Now, going back to your specific recommendation, do you think it is safe to go ahead and begin flying on R-20?

Captain **Frisbie**. Yes, sir, I do. And then I would like to recommend that whoever is in charge of all the carriers using that make sure that these kinds of disciplines to avoid human error failures are in place.

Mr. **Glickman**. Do you believe that both—let me start first with the Japanese air traffic control system, because the ability to operate in any of these routes basically, in some respects, depends upon their system as well as our system.

Do you believe the Japanese air traffic control system does everything possible to keep you from straying off course, or are they a relevant factor in all of this?

Captain **Frisbie**. I'm not sure in terms of their procedures or ability to monitor the progress of flights before entering maybe 300 miles from Hokkaido in the northernmost island of Japan. I think they are very professional in the way they do business. I think they designed the reporting points at the western end of that route system so that they can verify positions by radar. But I don't believe that they or we have the ability to monitor someone straying in between the area served by radar into the western end of the Aleutians and the northern end of Japan.

To answer your question, I think they're doing all they can, but I'm not really familiar with what they're doing.

Mr. **Glickman**. OK. A couple of other points and then I'll go on to some of the other members here.

You talked about how you're required to report the issue of compulsory check points along the way. I wonder if you could amplify that. How often are you required to report and should it be more frequent than it is now?

Captain **Frisbie**. Sir, on that track there are airways—I have a copy of a chart here which I could leave with you as well. But there are position reports along the airway—and I'll check some distances. Roughly every 280 or minus 90 miles along that whole composite route system in the area of red 20. From NEEVA it's 281 miles to NINO. NINO is not a compulsory check point, and yet it's the first one after you get in an area nearest that hostile country. It's not even required——

Mr. **Glickman**. So it ought to be a required checkpoint?

Captain **Frisbie**. It should be one. And the next one is NIPPI, which is 280 miles farther. So we're talking about 561 miles before reporting points, and we could do it every 280. They're already on our chart and in our flight plan.

Mr. GLICKMAN. So instead of an hour, you would be roughly a half-hour between——

Captain FRISBIE. Yes, sir.

Mr. GLICKMAN. Now, who would decide whether that's a required check point or not? Whose decision is that?

Captain FRISBIE. That's a function of the air traffic control system. These are designated by the FAA.

Mr. GLICKMAN. So if the FAA would make that change, then it would be required, at least by U.S. carriers flying that route?

Captain FRISBIE. It would be required. These are normally generated as a function of distance, and I think that in the normal course of business these reporting points were probably OK. But we're talking now about improving something until we have something like GPS.

Mr. GLICKMAN. Improving it because we're awfully darned close to hostile airspace.

Captain FRISBIE. Yes, sir. And in a sensitive area, perhaps we should use all of these disciplines that we would not have to use—for example, when we fly nonstop to Sydney from Los Angeles, we don't have these kinds of problems. Once an hour is enough.

Mr. GLICKMAN. Now, one other suggestion that has been made is to station ships, perhaps as we might have done years ago in the North Atlantic, navigational ships, ships that would provide the same kind of advice to pilots. How do you feel about stationing ships full time in the Western Pacific?

Captain FRISBIE. I would welcome—let me respond by saying I believe that we can do this quite routinely, quite safely, without them, by following the disciplines. However, to the extent that they are available, we used to use them at 30 north, 140 west, Ocean Station November in the Pacific; we had them, as you have already indicated in the Atlantic. They provided a useful service. I would welcome that in the interim.

Mr. GLICKMAN. OK.

Mr. McCandless.

Mr. MCCANDLESS. Thank you, Mr. Chairman.

Captain Frisbie, we seem to keep coming back to the intangible of the human error aspect of it, the training that goes on, that training results in the disciplines and discipline hopefully results in less mistakes, resulting in less human error. We catalog some of these.

We talked about the inaccurate data input, we have talked about complacency, and another one could possibly be fatigue; another one could be the multitude of instrumentation and design location which might lend itself to some type of standardization; wherein if you had a certain aircraft configuration, that button A would be in a certain position—it could be any kind of a button, depending upon what design the aircraft purchaser wished, but that button did the same thing in each aircraft.

In this human error area, how would you catalog those in terms of their importance?

Captain FRISBIE. Well, I would say in terms of complacency, we are always cautious and careful and reminding our people to avoid complacency. We do that by memorandums; we do that by what we call base news, publications to the airmen, and we send that message in training which occurs at least twice a year, and we talk about that on the line checks which occur frequently along the line. We just have to keep on our toes.

I don't know what part complacency played in that incident, but I would say that in a typical situation—and I understand from testimony this morning that there have been many errors in navigation, that complacency has played the largest part of the factors that you mentioned. Fatigue, of course that can be a factor, depending on the length of the flight, the diurnal factors of the flight, time of day, things like that. I'm not familiar in the case of Korean 7 just what those factors were in terms of fatigue, how long they had been on duty. I know that it was nighttime when the incident or the accident—when the loss occurred in Russian airspace.

As far as design goes, in this type of incident I don't believe it's a factor that you could measure in terms of cockpit design, button location and that kind of thing, in terms of a navigation error.

As Mr. Reynard earlier pointed out, each carrier specifies how they want the cockpit made up, and later they buy airplanes from each other, just like used cars, and they are different. The cost of changing, although all carriers attempt to standardize these panels, sometimes just forbids making minor changes for alternate procedures on a subsystem or something like that. Important changes are always made. I don't believe that design of the cockpit could play a part that you could measure in this kind of an incident.

Mr. McCandless. Knowing now, based upon what experience you had both as a command pilot and the information that has been made available to you since this incident, what suggestions would you have to such a committee as this, subcommittee, in the field where we have jurisdiction and hopefully some input into the system that would improve or place in the pilots of an international configuration a better set of circumstances to prevent this or minimize it from happening again?

Captain Frisbie. That's a good question, sir, and I would have to go back to what I've heard a little bit about on this global positioning system. I'm not knowledgeable or can't speak with any kind of detail to that system, but the little bit I know about it is that it's a system which, via satellites, would provide a line-of-sight kind of coverage to these same instruments we're accustomed to using everywhere in the world. This would be an incredible step ahead, so that we wouldn't be relying on this one INS system subject to human error failure.

I understand there is a large trust fund of ADAP funds which possibly could be directed to an earlier implementation of the global positioning system. This is key.

Mr. McCandless. But as far as the instrumentation in the cockpit today, it is sophisticated enough to be able to hold its own, given correct implementation of the data?

Captain Frisbie. Yes, sir, it is.

Mr. McCandless. Thank you, Mr. Chairman. Thank you, Captain.

Mr. Glickman. Thank you. Mr. Andrews?

Mr. ANDREWS. Thank you, Mr. Chairman.

Would one of the suggestions be that airlines be required to report at greater frequencies—the FAA's mandate that reporting be done every 500 miles, for instance, should it be 250 or 300 miles?

Captain FRISBIE. I think that depends on the nature of the particular route that we're flying. You can take into account all sorts of factors such as wind patterns. In certain areas, wind patterns are much more difficult to predict than others. But normally, the existing parameters are just fine.

I made that particular suggestion because I feel, after something like this, it is helpful, even though it may not be totally necessary, to improve a system. And this is an area where improvement would be easy, and I suspect that the FAA gentlemen that you will probably talk to later may want to do something like that. I know, from working with them in the past, that they will welcome input like this. I do believe in this case it would be helpful and desirable.

Mr. ANDREWS. Do you have any idea what the procedures are that, the cross-checking procedures of other airlines, other carriers, and specifically what kind of procedures 007 had?

Captain FRISBIE. No, sir, I'm not familiar at all with 007's procedures or the other major air carriers' procedures. Perhaps a sharing of this kind of information, or even a review of that by the FAA principal operations inspector or field offices might be appropriate as well.

I know that in the case of our airline the FAA people that we work with are very familiar with our procedures, they have approved our procedures by approving and certifying our aircraft operating manuals and all of our procedures. So, in effect, they have endorsed what we are doing, and they monitor it to make sure we comply, as well as our own in-house monitoring.

Mr. ANDREWS. Well, that brings up another question, and maybe someone from the FAA is in a better position to answer, Captain. But are there trade-outs? Do we converse with other carriers about their procedures? Does the FAA have some understanding and appreciation for the Korean Air Lines or other airlines around the world and what kind of cross-check procedures they have.

Captain FRISBIE. I'm afraid they could best answer their understanding of the other air carriers' procedures. There is a sharing of information amongst the carriers that belong to IOTA, for example, to ATA, and operations committees. There's an ATA—Air Traffic Association—operations meeting occurring just today. They get into broader subjects than disciplines within the cockpit.

I think that perhaps at the FAA level they could certainly monitor and spread this word as an outgrowth of this incident.

Mr. ANDREWS. Have you, as a pilot, ever been in the air and been in communication with foreign military aircraft?

Captain FRISBIE. No, I have not.

Mr. ANDREWS. Is it highly unusual for commercial pilots ever to be in communication with foreign military aircraft?

Captain FRISBIE. Yes, it would be.

Mr. ANDREWS. Do you know of any other incidents where aircraft have flown into foreign military space and been communicated by radio from those aircraft, from foreign military aircraft?

Captain **Frisbie**. I am not aware of specific examples. There have been cases where carriers have crossed borders, had misunderstandings, communicated with ground stations that were already serving the flight. But I know of no case where there has ever been communication between a foreign aircraft and an air carrier.

However, there are international procedures outlining that, frequencies to use and signals to use, lacking the communication that you're speaking of, signals of rocking wings, putting landing gear down, landing lights, things like that, to pass signals.

Mr. **Andrews**. Thank you.

Thank you, Mr. Chairman.

Mr. **Glickman**. Let me just follow up on this extra reporting point.

What you're saying—and this map you have given us here—is that there is a required reporting point at station NIPPI, right?

Captain **Frisbie**. Yes, sir, there is.

Mr. **Glickman**. And before that, you say there is nothing compulsory for about 500 miles, right?

Captain **Frisbie**. That's right. Before that, NEEVA is a compulsory position report, and in between is NINO. Is that on that——

Mr. **Glickman**. NINO is not on this map right here. Is it halfway in between?

Captain **Frisbie**. Yes, sir, it's exactly halfway in between, and I can leave you a copy of the current——

Mr. **Glickman**. What's curious, is there a directional, rather dramatic directional change between NEEVA and NIPPI? I mean, what I'm trying to figure out is, I'm wondering where the Korean airliner strayed off course. I can't recall from the transcript whether he accurately reported his NEEVA position point or not. What I'm trying to figure out is, had there been a second reporting point between NEEVA and NIPPI, would it be unlikely that he would have veered off course as he did?

Captain **Frisbie**. Well, it's hard to speculate on that, but my point here is that NINO is the first point after NEEVA where there is a track change. The track begins at NEEVA, the true track stays straight all the way to the western boundary, but the magnetic track changes by 10 degrees as a function of variation, and variation changes all around the world. So the magnetic heading changes 10 degrees, but the true heading doesn't change at all.

Now, if after flying 30 or 40 minutes he had used those disciplines we have talked about earlier and found that he was off course, he could have avoided being off course by a substantial amount. He would have learned it quicker and turned back to the south.

Mr. **Glickman**. You're saying if he had followed the disciplines he would have reported his position point——

Captain **Frisbie**. Yes, sir, that's correct. But in this case there was a compulsory point at NIPPI later, and at that point he apparently didn't pick up on it, either. So if he didn't do it at NINO, he may not have done it anyway.

Mr. **Glickman**. He may not have done it.

Captain **Frisbie**. I'm just saying that might help someone that could make a mistake and let it slip through all of those gates.

Mr. **Glickman**. Yes.

Mr. McCandless had one more question.

Mr. McCandless. Captain, a lot has been written about this incident, and some information today briefly touched on one aspect of it, and that is the personal relationship between members of the crew in the cockpit. In the case of foreign airlines, there is a great reluctance, we are told, for any of the junior officers to contradict the senior officer based upon their background and ethnic origin.

As a regional pilot doing flight checks on your senior members, have you found there to be any kind of a problem that should be addressed in this area?

Captain Frisbie. Well, I don't believe that there's a problem in this area at Pan American, or probably not at the other American carriers. I have heard those comments, too, and I really don't feel qualified to speak to them as relates to foreign carriers.

In our company we require this cross-check by the junior officers. And I can guarantee you, there is very little reluctance and there is no hesitancy really for someone to speak up. They are encouraged to do that, even if they think something is wrong.

Now, at Pan American the copilot is also required to have an ATR, that is, in the eyes of the FAA, he has taken all the tests pursuant for a requirement for him to be in command of the airplane. So we have two pilots on there that have met all of those tests and have had all of that training.

The more junior officer is also an experienced officer. He is required to monitor the progress, the comments, the callouts of the pilots between each other. He is trained in those callouts. If they fail to make one, he is required by procedure to interject and comment—"too fast, too high, too low," an altitude warning or something like that even. So those procedures are in place and don't need changing here, and I don't think they would be a factor.

Mr. McCandless. One other quick one.

In trying to prepare myself for this today, I understood in a situation such as Pan Am that there are five cross-checks required by your operating manual or procedure with respect to the INS system. Is that correct information?

Captain Frisbie. Yes, sir. I didn't count them. There are probably at least five, and I could review them if you wanted me to. But I think you have more than that, really.

Mr. McCandless. But that airline x, whether it be a national or an international carrier, is not by any convention, rule or regulation, of an international nature, required to do a similar type of check; the check system is that of the country or that of the company, depending upon who regulates that?

Captain Frisbie. That's correct.

Mr. McCandless. What would be the minimum that would be required of the Federal Aviation Administration in order to certify a carrier? Is there a minimum?

Captain Frisbie. I'm not really sure what those minimum requirements would be.

Mr. McCandless. So we could look into this and say well, maybe the necessary level of requirement mandated in terms of U.S. carriers needs to be reviewed.

Captain Frisbie. It may not need to be—well, reviewed in terms of is it adequate and is it being complied with.

Mr. **McCandless**. A cross-check.

Captain **Frisbie**. Yes. Those procedures and policies for foreign carriers are controlled where the aircraft are registered in their own foreign country, and their pilots are in that country.

Mr. **McCandless**. We have all these conventions that we have with respect to international aviation. It would appear to me that that would be something that would be certainly a part of that, to make sure that——

Captain **Frisbie**. Yes, sir. I can assure you that at Pan American, if we have procedures that would be helpful to others, we would be happy to share them and work in any kind of cooperative spirit with carriers either in this country or abroad to help them improve those procedures.

Mr. **McCandless**. Thank you, Captain. It was very informative.

Thank you, Mr. Chairman.

Mr. **Glickman**. Just one final question.

Do you think there is any carrier in their right mind, or pilots in their right mind, that would have taken the route that the KAL 007 took in order to save time and to save fuel?

Captain **Frisbie**. No, sir, that could not happen.

Mr. **Glickman**. OK. I want to thank you very much for your testimony.

I might tell you just an interesting anecdote, since you fly quite a bit. I was in the Soviet Union in early July and we flew from southern Armenia to Rome, and the most direct route would be over Turkey and across the Italian peninsula. But we could not get navigational clearance across there because the Soviets told us that there was some question as to whether our plane would be in danger flying over Turkish air space, which, of course, is a NATO ally. So we flew over Soviet air space significant additional mileage in order to avoid being shot down over Turkish air space, which I just thought was kind of a curious irony to all of this.

Captain **Frisbie**. It certainly is.

Mr. **Glickman**. Thank you very much.

Captain **Frisbie**. Thank you, sir.

Mr. **Glickman**. Now we'll go back to the regular order, back to the FAA, Walt Luffsey. Is Walt here?

You may proceed, Mr. Luffsey. It's a pleasure to have you here.

STATEMENT OF WALTER S. LUFFSEY, ASSOCIATE ADMINISTRATOR FOR AVIATION STANDARDS, FEDERAL AVIATION ADMINISTRATION, ACCOMPANIED BY NEAL BLAKE, DEPUTY ASSOCIATE ADMINISTRATOR FOR ENGINEERING, FEDERAL AVIATION ADMINISTRATION

Mr. **Luffsey**. Thank you, sir.

Mr. Chairman, members of the subcommittee, I am pleased to appear before the subcommittee to discuss the kinds of air carrier navigation systems in use today. With me is Neal Blake, FAA's Deputy Associate Administrator for Engineering.

In the North Pacific, or NOPAC, for operations within the Anchorage and Tokyo Flight Information Regions airspace in the area transited by Korean Air Lines flight 007, U.S. air carriers who will fly at flight levels 280 through 450 are required by the FAA to have one of the following types of navigation systems: An approved dual inertial navigation system, INS; an approved dual OMEGA navigation system, an approved system comprised of an inertial navigation system and an OMEGA navigation system; or an approved Doppler radar navigation system and an inertial navigation system or OMEGA navigation system.

International standards contained in ICAO annex 2 require an aircraft, which is not under visual flight rules, to have—and I quote: "navigation equipment which will enable it to proceed: (a) in accordance with its operational flight plan; and (b) in accordance with the requirements of air traffic services. * * *"

While the U.S. operations procedures permit the use of different types of navigation systems for oceanic use, and ICAO rules are not specific on equipment, a survey of NOPAC traffic between January 10 and 23, 1982, showed that all aircraft flying the composite routes—those are R-2, R-80, A-90, R-91, and G-44—were equipped with at least INS, and, for that matter, all traffic in NOPAC was equipped with INS except for one carrier which has now equipped its oceanic aircraft with INS. It is now common international practice for oceanic aircraft to use INS, a combination of INS and OMEGA, or OMEGA.

Joint United States/Japanese monitoring of navigation accuracy at the end points of the NOPAC composite route system between March and September 1982 found only one aircraft with a lateral position error greater than 10 miles. That aircraft was 17 nautical miles from centerline, well within the accuracy required for the safety of aircraft using the composite routes. The demonstrated navigation performance of both INS and OMEGA is adequate to meet the demands for safe flight in the NOPAC composite route system where aircraft at the same altitude are separated by 100 nautical miles. The maximum permissible error for INS is 2 nautical miles per hour. Actual demonstrated performance on over 500,000 flights has shown that the average INS drift is, in fact, about 1 nautical mile per hour. The average time in the NOPAC composite route system is approximately 5 hours. Consequently, the maximum permissible navigation error for INS is about 10 nautical miles at the end point. OMEGA in the NOPAC has a demonstrated accuracy of better than 4 nautical miles.

The operation of both INS and OMEGA is similar, except for the INS alinement prior to use. For either system to be useful, the operator must insert the desired navigation information. The information consists of trip origin, destination, and, if required, intermediate way points. This data is most commonly entered as latitude and longitude out to tenths of minutes.

Both INS and OMEGA have good operational histories. Nevertheless, the FAA requires U.S. air carriers to have dual systems so that redundancy is provided. Since both systems must be operating at departure, many carriers have installed three INS units or a dual INS with an OMEGA as backup.

In addition to prescribed types of navigation equipment, all U.S. air carriers operating large turbojet aircraft are equipped with airborne weather radar for the detection of thunderstorms and other potentially hazardous weather conditions considered detectable with such equipment. The airborne weather radar must be operational prior to departing under instrument flight rules or night visual flight rules over a route when current weather reports indicate that thunderstorms, or other detectable weather conditions, may reasonably be expected along the route to be flown. ICAO recommended practices are comparable to these FAA requirements.

When operating over the NOPAC composite route structure, the airborne weather radar required of U.S. air carriers must be capable of day and night ground mapping. The radar must be operational prior to departing over these routes and must be used continuously by the flightcrew to monitor flight progress over these routes.

With respect to the KAL tragedy, the members of this subcommitee are aware that the United States is participating in the investigation being conducted by the South Korean Government. To date, no formal conclusions have been reached concerning the reason or reasons why flight 7 would have been off course. Accordingly, I can't shed any additional light on this topic, nor am I in a position to speculate about the reasons given the pendency of the investigation. I can say we have gone over the communications between our controllers and flight 7 and have found nothing which would have provided our controllers with any indication that the plane was off course. All communications up to and including the last transmission received by the FAA were of a normal, routine nature. For your information, I am appending to my prepared statement a transcript of those communications.

Mr. Chairman, that completes my prepared statement. I will be pleased to respond to any questions you may have at this time.

[The prepared statement of Walter Luffsey follows:]

STATEMENT OF WALTER S. LUFFSEY, ASSOCIATE ADMINISTRATOR FOR AVIATION STANDARDS, BEFORE THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON TRANSPORTATION, AVIATION, AND WEATHER, CONCERNING NAVIGATION SYSTEMS. SEPTEMBER 19, 1983.

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before the Subcommittee to discuss the kinds of air carrier navigation systems in use today. With me today is Neal Blake, FAA's Deputy Associate Administrator for Engineering.

In the North Pacific (NOPAC) for operations within the Anchorage and Tokyo Flight Information Regions airspace in the area transited by Korean Air Lines Flight 007, U.S. air carriers who will fly at Flight Levels 280 through 450 are required by the FAA to have one of the following types of navigation systems: an approved dual Inertial navigation system (INS); an approved dual OMEGA navigation system; an approved system comprised of an Inertial navigation system and an OMEGA navigation system; or an approved Doppler radar navigation system and an Inertial navigation system or OMEGA navigation system. International standards contained in ICAO Annex 2 require an aircraft, which is not under VFR rules, to have "navigation equipment which will enable it to proceed: a) in accordance with its operational flight plan; and b) in accordance with the requirements of air traffic services...."

While the U.S. operations procedures permit the use of different types of navigation systems for oceanic use, and ICAO rules are not specific on equipment, a survey of NOPAC traffic between January 10-23, 1982, showed that all aircraft flying the composite routes (R-20, R-80, A-90, R-91, and G-44) were equipped with at least INS, and, for that matter, all traffic in NOPAC was equipped with INS except for one carrier which has now equipped its oceanic aircraft with INS. It is now common international practice for oceanic aircraft to use INS, a combination of INS and OMEGA, or OMEGA.

Joint U.S./Japanese monitoring of navigation accuracy at the end points of the NOPAC composite route system between March and September 1982, found only one aircraft with a lateral position error greater than 10 nautical miles. That aircraft was 17 nautical miles from centerline, well within the accuracy required for the safety of aircraft using the composite routes. The demonstrated navigation performance of both INS and OMEGA is adequate to meet the demands for safe flight in the NOPAC composite route system where aircraft at the same altitude are separated by 100 nautical miles. The maximum permissible error for INS is 2 nautical miles per hour. Actual demonstrated performance on over 500,000 flights has shown that the average INS drift rate is, in fact, about one nautical mile per hour. The average time in the NOPAC composite route system is approximately 5 hours; consequently the maximum permissible navigation error for INS is about 10 nautical miles at the end point. OMEGA in the NOPAC has a demonstrated accuracy of better than 4 nautical miles.

The operation of both INS and OMEGA is similar except for the INS alignment prior to use. For either system to be useful, the operator must insert the desired navigation information. The information consists of trip origin, destination, and, if required, intermediate "way points." This data is most commonly entered as latitude and longitude out to tenths of minutes.

Both INS and OMEGA have good operational histories. Nevertheless, the FAA requires U.S. air carriers to have dual systems so that redundancy is provided. Since both systems must be operating at departure, many carriers have installed three INS units or a dual INS with an OMEGA as back-up.

In addition to prescribed types of navigation equipment, all U.S. air carriers operating large turbojet aircraft are equipped with airborne weather radar for the detection of thunderstorms and other potentially hazardous weather conditions considered detectable with such equipment. The airborne weather radar must be operational prior to departing under IFR or night VFR over a route when current weather reports indicate that thunderstorms, or other detectable weather conditions, may reasonably be expected along the route to be flown. ICAO recommended practices are comparable to these FAA requirements.

When operating over the NOPAC composite route structure, the airborne weather radar required of U.S. air carriers must be capable of day and night ground mapping. This radar must be operational prior to departing over these routes, and must be used continuously by the flight crew to monitor flight progress over these routes.

With respect to the KAL tragedy, the Members of this Subcommittee are aware that the United States is participating in the investigation being conducted by the South Korean Government. To date no formal conclusions have been reached concerning the reason or reasons why Flight 007 would have been off course. Accordingly, I can't shed any additional light on this topic nor am I in a position to speculate about the reasons given the pendency of the investigation. I can say we have gone over the communications between our controllers and Flight 007 and have found nothing which would have provided our controllers with any indication that the plane was off course. All communications up to and including the last transmission received by the FAA were of a normal, routine nature. For your information, I am appending to my prepared statement a transcript of those communications.

Mr. Chairman, that completes my prepared statement. I will be pleased to respond to questions you may have at this time.

U.S. Department
of Transportation
**Federal Aviation
Administration**

Memorandum

Subject: Consolidated transcription on Korean flight 007 on 8-31-83 from Anchorage Tower, Anchorage Center and Anchorage International Flight Service Station

Date: September 11, 1983

From: Joseph A. Beaudoin
Accident/Incident Analysis Branch

Reply to Attn. of: AAT-340

To:

Agencies making transmissions	Abbreviations
Anchorage Tower	ANC APCH
Anchorage Air Route Traffic Control Center:	
Sector RD 5/6	D 5/6
Sector D 2/3	D 2/3
Sector D 10/11	D 10/11
Anchorage International Flight Service Stn.	IFSS or E459
Tokyo Air Route Traffic Control Center	TKY CTR
Korean Air Lines Flight 007	KE007
Korean Air Lines Flight 015	KE015
United Air Lines Flight 18	UA18
Unknown Source	UNK

This transcription is in a sequential order and will identify the source from whence it was derived from at the beginning of each different segment. Duplications have been eliminated. All times indicated will be in GMT (Greenwich mean time).

Anchorage Tower

1250:12	KE007	Uh clearance Korean zero zero seven uh have information sierra Seoul at three one zero
1250:18	ANC APCH	Korean Air zero zero seven heavy is cleared to Seoul via the Anchorage eight departure then as filed climb and maintain flight level three one zero departure frequency one one eight point six squawk six zero seven two
1250:34	KE007	Korean zero zero seven cleared to Seoul Anchorage eight departure climb and maintain three one zero one one eight six six zero seven two
1250:43	ANC APCH	Korean zero zero seven heavy read back was correct

1250:59	KE007	Ground Korean zero zero seven request push gate two
1251:04	ANC APCH	Korean Air zero zero seven heavy push at your discretion plan runway three two
1251:08	KE007	Roger
1255:40	KE007	Uh ground Korean Air zero zero seven taxi
1255:45	ANC APCH	Korean Air zero zero seven heavy taxi to runway three two
1255:50	KE007	Runway three two roger
1258:33	KE007	Korean zero zero seven ready for takeoff
1258:36	ANC APCH	Korean Air zero zero seven heavy roger departure frequency will be one one eight point three same as tower cleared for takeoff runway three two
1258:45	KE007	Roger one one eight three
1301:12	ANC APCH	Korean Air zero zero seven heavy Anchorage departure radar contact climb and maintain flight level three one zero turn left heading two two zero
1301:22	KE007	Roger two two zero climb and maintain three one zero roger
1302:40	ANC APCH	Korean Air zero zero seven heavy proceed direct Bethel when able
1302:45	KE007	Roger uh proceed direct to Bethel roger
1304:39	ANC APCH	Handoff forty seven line
1304:45	D 5/6	Go ahead
1304:47	ANC APCH	About seven west of the VOR Korean Air zero zero seven heavy going direct Bethel
1304:51	D 5/6	He's radar
1304:54	ANC APCH	He's off on the hour (unintelligible) TD
1305:13	ANC APCH	Korean Air zero zero seven heavy contact Anchorage Center one two five point seven good day
1305:18	KE007	(unintelligible) good day

Anchorage ARTCC Sector RD 5/6

1305:03	KE007	Anchorage Korean Air zero zero seven leaving five thousand for three one zero good morning

1305:09	D 5/6	Good morning Korean Air zero zero seven rog
1327:50	D 5/6	Korean Air zero zero seven radar service is terminated contact Center one two five point two good morning
1327:53	KE007	two five two good morning

Anchorage ARTCC Sector D 2/3

1328:01	KE007	Anchorage Center Korean Air zero zero seven good morning now leaving three zero zero for three one zero
1328:06	D 2/3	Korean Air zero zero seven roger report Bethel
1328:11	KE007	Report Bethel roger
1350:09	KE007	Anchorage Korean Air zero zero seven
1350:12	D 2/3	Korean Air zero zero seven go ahead
1350:14	KE007	Zero zero seven Bethel at four niner flight level three one zero estimate NABIE at one four three zero two one niner decimal zero minus four niner two niner five diagonal two five
1350:28	D 2/3	Korean Air zero zero seven roger report NABIE to Anchorage on one two seven eight
1350:33	KE007	one two seven eight roger
1350:42	D 10/11	Go ahead
1350:43	D 2/3	Korean Air zero zero seven says NABIE one four three zero TJ
1350:47	D 10/11	KD

Anchorage ARTCC Sector D 10/11

1432:21	D 10/11	Korean Air zero zero seven Anchorage Center
1432:32	D 10/11	Korean Air zero zero seven Anchorage Center
1433:37	D 10/11	Korean Air zero zero seven Anchorage Center
1433:47	UNK	(unintelligible)
1433:52	D 10/11	Korean Air zero zero seven Anchorage Center how do you read
1434:18	UNK	*(Well wait a minute call again please)

*(best interpretation)

BEST COPY AVAILABLE

1434:37	D 10/11	Korean Air zero zero seven Anchorage Center
1434:50	UNK	*(Three three zero I can't wait a minute)
1434:54	UNK	*(Three three zero okay I got it hello) *(best interpretation)
1435:02	KE015	Anchorage Korean Air zero one five
1435:08	D 10/11	Korean Air zero one five Anchorage Center go ahead
1435:11	KE015	Roger Korean Air zero one five ah forwarding report ah Korean zero zero seven position NABIE one four three two flight level three one zero estimating ah NEEVA one five four nine fuel remaining two zero zero decimal zero minus four nine spot two five zero diagonal six zero go ahead
1435:38	D 10/11	Korean Air zero one five roger ah have Korean Air zero zero seven report NEEVA to Anchorage Center one two eight decimal two
1435:52	KE015	Roger NEEVA one two eight decimal two good day
1436:00	KE015	Zero zero seven
1436:12	E459	Four five nine
1436:14	D 10/11	Four five nine Center channel eleven reference ah Korean Air zero zero seven
1436:19	E459	Go ahead
1436:21	D 10/11	Ah you can cancel it
1436:22	E459	GB
1436:23	D 10/11	KD

Anchorage International Flight Service Station

1444:10	KE007	Anchorage Radio Korean Air zero zero seven
1444:15	IFSS	Korean Air zero zero seven Anchorage
1444:20	KE007	Roger Korean Air zero zero seven position NABIE one four three two three one zero estimating NEEVE one five five three remaining fuel two zero zero decimal zero minus four nine wind two five zero diagonal five ah diagonal six five ah selcal code golf kilo foxtrot hotel requesting level three three zero when available

1444:50	IFSS	Korean zero zero seven Anchorage understand NABIE one four three two three one zero NEEVE one five five three is that correct
1445:00	KE007	Affirmative Korean Air zero zero seven thats affirmative
1445:20	IFSS	Korean zero zero seven Anchorage roger progress standby for sel check
1445:30	KE007	Korean zero zero seven selcal ok thank you
1445:40	IFSS	Korean zero zero seven Anchorage roger and ah contact Anchorage Center now one two seven decimal eight make your request with them
1445:40	KE007	Roger one two seven eight roger

Anchorage ARTCC Sector D 10/11

1600:39	KE015	Anchorage Center Korean Air zero one five
1600:43	D 10/11	Korean Air zero one five Anchorage Center go ahead
1600:46	KE015	(unintelligible) relay NEEVA report for zero zero seven their position NEEVA one five five eight flight level three one zero estimate NIPPI one seven zero eight fuel remaining one six one decimal zero minus four eight spot two seven zero diagonal five five go ahead
1601:20	D 10/11	An Korean Air zero one five understand this is a position report for Korean Air zero zero seven and advise Korean Air zero zero seven to ah report NIPPI to enroute radio thank you very much
1601:32	KE015	Roger

Anchorage International Flight Service Station

1603:55	KE007	Anchorage Radio Korean Air zero zero seven
1604:05	KE007	Anchorage Korean Air zero zero seven
1604:12	IFSS	United one eight Anchorage radio
1604:21	KE007	Anchorage radio Korean Air zero zero seven
1604:31	IFSS	Aircraft calling Anchorage on two niner one zero I'm unable to copy you would you give me a radio check on five six two eight now
1604:49	UA18	Anchorage radio United one eight

1604:51	IFSS	United one eight I have you loud and clear this frequency go ahead sir
1604:58	UNK	(unintelligible - sounds like KE007 & UA18 both talking)
1605:06	IFSS	United one eight ATC is requesting you forward one five zero west progress and say again your request
1605:10	UA18	Ok we're requesting flight level three seven zero we crossed ah (KE007---Anchorage radio Korean Air zero zero seven) four eight north one five zero west one five zero zero three five zero four seven north one four zero west one five five one (unintelligible) minus four six (KE007---Korean Air zero zero seven) go ahead
1605:35	IFSS	United one eight roger I copied that earlier my mistake sir thank you I have your request and will give it back to ATC standby
1605:41	UA18	Thank you

Anchorage ARTCC Sector D 10/11

1606:25	KE015	Anchorage Center Korean Air zero one five now reaching flight level three five zero
1606:31	D 10/11	Korean Air zero one five roger flight level three five zero and would you ask Korean Air zero zero seven if he would like higher altitude prior to NIPPI
1606:40	KE015	Ah yes zero zero seven requested three three zero
1606:44	D 10/11	And ATC clears Korean Air zero zero seven climb and maintain flight level three three zero report reaching through you or through enroute radio
1606:53	KE015	Roger they are now leaving three one zero for three three zero and (unintelligible) Korean Air zero zero seven
1607:04	D 10/11	Roger
1610:30	KE015	Anchorage Center Korean Air zero one five
1610:34	D 10/11	Korean Air zero one five go ahead sir
1610:37	KE015	(unintelligible) three three zero Korean Air zero zero seven we talk on one two three four point zero
1610:45	D 10/11	Korean Air zero one five thank you and report NIPPI to enroute radio have a good flight
1610:50	KE015	Good morning
1612:35	TKY CTR	This is Tokyo Center
1612:37	D 10/11	Anchorage Center two transfers first Korean Air zero zero seven

1612:44	TKY CTR	Go ahead
1612:45	D 10/11	Korean Air zero zero seven flight level three three zero NIPPI one seven zero eight the next Korean Air zero one five
1612:55	TKY CTR	(unintelligible)
1612:56	D 10/11	Korean Air zero one five three five zero NIPPI one seven one four go ahead
1613:04	TKY CTR	Roger Korean zero zero seven NIPPI ah ah Korean zero zero seven flight level three three zero NIPPI one seven zero eight and the Korean zero one five flight level three five zero NIPPI one seven one four India Alpha
1613:19	D 10/11	Thank you Tango Alpha
		Anchorage International Flight Service Station
1623:00	IFSS	Calling Anchorage on five six say again your call sign and go ahead sir
1623:06	KE007	Korean Air zero zero seven on five six radio check
1623:11	IFSS	Korean Air zero zero seven Anchorage three by three
1623:16	KE007	Thank you

END OF TRANSCRIPT

Mr. GLICKMAN. Mr. Luffsey, I appreciate your lack of desire to give us a cause for the accident, but I'm wondering, since this is your area, I wonder if you might share for us a variety of options of what could have happened, why this plane strayed off course.

Mr. LUFFSEY. Sir, it would have to be speculation. The range, as testified this morning, of the types of things that could have occurred, based on what we have seen in reports so far, I believe that it would range from human error to equipment error, if, in fact, the equipment was involved in this particular deviation. Beyond that, I would hate to speculate any at all.

Mr. GLICKMAN. Does your transcripts refer to any radio trouble the plane was having?

Mr. LUFFSEY. There were no indications of radio trouble. According to the transcripts, there were two cases that I recall that reflect a relay of information, but not—that is a normal practice.

Mr. GLICKMAN. That does not necessarily mean radio trouble, that there was a relay of information?

Mr. LUFFSEY. That's right.

Mr. GLICKMAN. One of the themes that we have been talking about today is the procedures that airlines use for checking initialization and subsequent functioning of the INS system. You have been in this room and you've heard the Pan Am pilot testify according to a fairly elaborate system of checking those systems.

What sort of regulatory procedures do you have to insure that airplanes and airplane pilots do, in fact, engage in proper procedures to check their INS and other navigational systems?

Mr. LUFFSEY. As regards U.S. operators, all training programs are approved by FAA. Those programs are based on advisory material prepared by FAA. The testimony given by Captain Frisbie indicates one such system, and the procedures associated therewith are excellent, FAA-approved procedures.

Mr. GLICKMAN. Are they different, for example, than the procedures that Northwest or United might use in flying that corridor?

Mr. LUFFSEY. Not fundamentally different. There may be nuances because of the kind of operation, but in general, the training programs are specifically checked and they are in conformance with the material that we provide.

Mr. GLICKMAN. Now, what about foreign carriers?

Mr. LUFFSEY. We do not have direct surveillance over foreign carriers, other than the assigned principal, who insures compliance with part 129 of our regulations.

Mr. GLICKMAN. And what is part 129?

Mr. LUFFSEY. Part 129 deals with, in less specific detail, not procedures, not training programs and the like, but what the requirements are for international operation.

Mr. GLICKMAN. So what would be those? That they have an operating navigational system, or——

Mr. LUFFSEY. In general, in compliance with the annex of ICAO, that we insure they are in compliance with the annex——

Mr. GLICKMAN. So the Korean airliner that left this country in New York and went to Anchorage and Seoul, it was under no specific regulatory requirement from the FAA as to the operations of its navigational system?

Mr. LUFFSEY. That's correct.

Mr. GLICKMAN. And that's true with all foreign carriers?

Mr. LUFFSEY. Except as they enter U.S. air space, and operating in U.S. air space, they must be properly equipped and must comply with ATC procedures for the United States.

Mr. GLICKMAN. Now, I assume that most foreign carriers would not want to jeopardize the safety of their traveling public, but I'm wondering whether there ought to be some sort of international convention which in a sense functions with respect to all carriers like the FAA does with regard to domestic carriers, on the training of people in the use of these systems and the operation of these systems.

Mr. LUFFSEY. The International Civil Aviation Organization standards are requirements levied on all international carriers.

Mr. GLICKMAN. Are there ICAO standards—just 1 second. This will be one long bell.

Are there meaningful ICAO standards that deal with the issue of navigational systems?

Mr. LUFFSEY. They are individualized as to State. It's up to the State of ownership or operation of the vehicle to comply with international standards as parties to the convention.

Mr. GLICKMAN. Well, then, are the ICAO standards a sham, don't do anything with respect to really enforcing the proper standards with respect to their regional carriers, state-owned carriers?

Mr. LUFFSEY. I don't think I could place them in the category of a sham, sir. As I stated in the opening statement, they require the necessary equipment and compliance with the procedures in the State of operation.

Mr. GLICKMAN. Well, I think what we could be seeing here—and I'm not saying this is the cause of the accident—is a tremendous regulatory gap between the United States, which has effective standards and compliance on navigational systems and training—some carriers may, in fact, equal those; some may not—and passengers flying on some of those carriers, their lives could be being jeopardized by not being subject to the same kind of standards that our carriers are.

I think that ought to be of concern to the FAA in trying to insure some standardization of those navigational standards.

Mr. LUFFSEY. Of course, sir, we work very carefully through ICAO to establish international standards that are necessary for the safety of U.S. passengers.

Mr. GLICKMAN. Well, I would hope that one of the things that we're doing during our frequent meetings in Montreal is not only looking and blasting the Russians—which they ought to be blasted—but looking for some ways to protect U.S. passengers that are flying on some of these foreign carriers to insure that those carriers are, in fact, subject to the same requirements. Some may be.

For example, are you aware of Korean Air Lines, anything within their manuals, their instruction manuals, on the operation of navigational systems or the functioning of the equipment or the training of their pilots?

Mr. LUFFSEY. I am not directly personally aware. That is a part of an ongoing investigation, however, sir.

Mr. GLICKMAN. It is.

Mr. LUFFSEY. Yes.

Mr. GLICKMAN. So you're not right now aware of what back-up systems KAL uses or anything like that?

Mr. LUFFSEY. As regard the vehicle itself, I do know of the equipment and we understand that it is a standard configuration with triple INS and the standard VOR's, multiple VOR, DME, multiple ADF, et cetera.

Mr. GLICKMAN. Have you physically seen their operational procedures of the airline?

Mr. LUFFSEY. I have not; no, sir.

Mr. GLICKMAN. Is that in the hands of the FAA now?

Mr. LUFFSEY. It would be, under the current investigation.

Mr. GLICKMAN. One of the ideas would be to require any foreign carrier that wants to fly into the United States would be to basically be subject to the same requirements that our domestic carriers would be, because I assume it would be carrying U.S. passengers.

Have you entertained the throught of going that far?

Mr. LUFFSEY. As you know, the Administrator, even now, is in Monteal working the ICAO process, and has been most recently this past week. He is personally dealing with that, and I am not a party to all the details of that discussion. However, again we work very closely with ICAO to insure U.S. safety.

Mr. GLICKMAN. OK.

What can we learn from the flight recorder when or if it's ever recovered, or if we ever get our hands on it?

Mr. LUFFSEY. This particular flight recorder would have I think in excess of 40 channels of recorded information. Of course, the fundamental purpose of that would be to reconstruct the events as contained on the flight data recorder. Having reconstructed, we could reach some conclusions from it. But beyond that, I can't even speculate what we might find on it.

Mr. GLICKMAN. OK.

Now, you were in the room when the chief regional pilot for Pan Am said that R-20 ought to be reopened?

Mr. LUFFSEY. Yes, sir.

Mr. GLICKMAN. I wonder if you have any comments on that, together with any comments you would have on what action should be taken to eliminate the possibility of straying into Soviet airspace.

Mr. LUFFSEY. OK. Well, fundamentally, we believe that the route system, including R-20, is a safe route system. The action to suspend temporarily the service was a prudency measure that we effected, as did the Japanese Government effect, principally as a prudency measure, until such time as we complete the investigation or much further along in the investigation than we are currently.

Mr. GLICKMAN. What are you doing now to keep planes from straying into this space? Is there anything in particular the FAA is doing, any operating manual changes, any regulatory changes?

Mr. LUFFSEY. Not specifically per aircraft. We are, of course, emphasizing the necessity, as we have, to insure proper input procedures and proper cross-check, not only initially, but along the way points. That is a standard for us. Nothing beyond that.

Mr. GLICKMAN. What advantages do you think the GPS, the satellite system, would have, and are you working to accelerate this in the area of navigation for civil aircraft?

Mr. LUFFSEY. Of course, the direct relationship to Korean Air Lines 007, we don't really know what happened with 007, so that relationship is unknown.

Let me turn to Mr. Blake on the GPS system and let him elaborate.

Mr. GLICKMAN. OK.

Mr. BLAKE. Thank you.

No, Mr. Chairman, we have been working with the Department of Defense and the Office of the Secretary of Transportation on the definition of the future mix of navigation systems, and the GPS has been one of the systems under a great deal of discussion and study.

As it might have affected this situation, I think the GPS might have offered slightly better accuracy in position and perhaps less preflight time required to prepare the system. On the other side, if the error had, in fact, been in entering the data, a similar error might have occurred in the GPS system because that, like INS, like OMEGA, is an area navigation system where coordinates do have to be entered.

Mr. GLICKMAN. But is the FAA working to move into this system of navigation?

Mr. BLAKE. Yes. In fact, we had identified three or four items which required resolution so that the system could be used by the civil community. During this past year we believe that at least two of those may have been addressed and satisfactory answers found.

Specifically, the accuracy of the system, which will be available to civil aviation, is now given as 100 meters, which we feel is adequate for most search——

Mr. **Glickman**. One hundred meters. So you would know where a plane was at any time within 300 or 330 feet?

Mr. **Blake**. Yes; that's correct.

Also, we understand that there has been an announcement made that the system would be available for civil users under all conditions except perhaps direct attack of this country.

There are several additional areas that are under discussion and we hope for resolution. One is the manner of integrity, the ability to shut down a satellite if it starts to give out bad information within a short time period. Another one is reliability. That's the ability to provide worldwide coverage for navigation and to provide some back-up in the case of satellite failure, which our studies have shown requires some additional satellites.

Mr. **Glickman**. Was there a problem that the Defense Department wanted to charge civilian users some sort of a user fee for this system and that was one of the impediments to moving the process along?

Mr. **Blake**. Yes. There had been a study done on a method of cost recovery, which was not compatible perhaps with our legislation, and also we believed allocated too large a share of the cost of the GPS system to general aviation—not commercial aviation but to general aviation. That question is being discussed at the top levels of both the Department of Defense and FAA and I think perhaps there will be a different proposal there before too long.

Mr. **Glickman**. Thank you.

Mr. McCandless.

Mr. **McCandless**. Thank you, Mr. Chairman.

Mr. Luffsey, you heard Mr. Reynard talk about the data he's compiling, and this is a contractual agreement that NASA has with the FAA. This information then is forwarded to you at some point in this contractual agreement.

When you receive that information and the investigations that have resulted in the development of that information, what procedures does the FAA have in analyzing that with respect to what they should or shouldn't do possibly in future regulations, preventive measures, et al?

Mr. **Luffsey**. There are several systems of reporting to us. NASA reports via alert bulletins, those things that normally require immediate attention, corrective action, as required. That is done by the appropriate functional organization within FAA.

As regards the 21 reports he discussed this morning relative to INS, I have personally reviewed those, as did my Office of Aviation Safety. Looking through those, and looking through the infinitely small number of those compared to the total, the multiple thousands of operations and literally millions of hours of operation with INS, it is a very small number. And most of those are not INS equipment based. In fact, as I recall those, none of those really were. The INS performed as it should.

The fundamental problem was either a programing error or improper cross-check or improper application of the equipment to the given operation.

Mr. McCandless. Now that you've made some kind of a judgment call after analyzing this information, what is the next step? Do you communicate with the airlines; do you have an association of airlines that you discuss; do you go to the international convention at its next meeting to discuss possible changes? How do you implement this where it is obvious that there needs to be something——

Mr. Luffsey. If there were obviously corrective action required, it would depend on the case. And let's take this particular example.

If we needed to change something for U.S. operators, we could do that directly with each of the operators under operation specifications, if we needed to do so——

Mr. McCandless. How do you do that physically? Do you send out a bulletin, send out a requirement? How do you handle that?

Mr. Luffsey. In that particular case, if we're going to individual operators, we would probably alert our principal operations inspector by operations bulletin, which in turn would be implemented with each of the carriers.

If we needed general regulatory processes, then we would go through a regulatory approach to do so under the Administrative Procedure Act. If we wanted to bring it to the attention of the internatinal civil aviation authorities, we would do so via paper and bring it to an appropriate working group or to the total body, the assembly itself, if necessary.

Mr. McCandless. Do you find a favorable climate when you do this on an international convention basis?

Mr. Luffsey. I think the answer to that is generally, when the FAA proposes something, we have favorable reaction thereto.

Mr. McCandless. Let's diverse our comments from navigational systems to maintenance of aircraft, which can certainly cause equal problems.

Would you consider the average maintenance of the international carrier that is not a U.S.-based operation to be equal to or sufficient, or do we have some weaknesses there that the FAA is aware of and would like to see corrected?

Mr. Luffsey. I would consider it certainly in compliance with minimum standards which are stipulated by FAA under regulation, under the part 129 procedures. They must operate by international maintenance procedures, and I would say they would be equivalent on that basis.

Mr. McCandless. How do you establish whether or not they are operating under your minimum requirements?

Mr. Luffsey. I am doing this based on the requirements for their operation. We actually have no direct surveillance over their maintenance system if it is not a U.S.-registered, U.S.-operated aircraft.

Mr. McCandless. So if I am a foreign airline, irrespective of what part of the world I operate in, as long as I say I am complying with your minimum standards, that is all that's necessary to receive and carry U.S. citizens throughout the world?

Mr. Luffsey. That's correct.

Mr. McCandless. Thank you.

Thank you, Mr. Chairman.

Mr. **Glickman**. I appreciate your testimony here. Thank you very much.

Mr. **Luffsey**. Thank you, sir.

Mr. **Glickman**. Our next witness is Capt. Henry Duffy, president of the Air Line Pilots Association. I appreciate your being here. We're just going to continue on and finish these hearings and not break for lunch. That way we will not have any rollcall votes and we can move fairly quickly.

Thank you very much, Captain Duffy, for coming. We appreciate your courtesy in agreeing to a slight schedule change here. One of your pilots, I think, was testifying, so——

Captain **Duffy**. We thought that was a good excuse, Mr. Chairman.

Mr. **Glickman**. Yeah. OK, why don't you proceed.

STATEMENT OF CAPT. HENRY A. DUFFY, PRESIDENT, AIR LINE PILOTS ASSOCIATION, ACCOMPANIED BY JOHN O'BRIEN, DIRECTOR, ENGINEERING AND AIR SAFETY DEPARTMENT, ALPA

Captain **Duffy**. We appreciate the opportunity to be here. With me is Mr. John O'Brien, who is the director of our engineering and air safety department. As you know, ALPA represents the professional interests of 34,000 pilots on some 47 carriers in this country. I would like to present in a brief statement the views and efforts of the line pilot on the Korean Air Lines flight 007 incident and on the long-range navigation systems used in today's air transportation system.

I can't say that I am happy to be here, because the subject which brings us together is the loss of 269 human lives.

Because airline pilots bear the ultimate responsibility for the safety of their passengers, we seek actions that will guarantee the safety of civilian air passengers. If the Soviet Union wants to continue civil air commerce with the rest of the world, it must act civilly. That means obeying the spirit and the letter of the rules governing international air traffic. ALPA has taken an active role in seeking to force the Soviet Union to guarantee the safety of international airways.

Let me outline what we have done thus far:

Shortly after the facts of the downing of the Korean Air Lines 747 became known, the State Department asked ALPA and other aviation groups for suggested actions. Our advice was, and is, that any actions that are taken be in the same arena as the provocation; namely, commercial air traffic. We recommended that all flights to Moscow be banned and that free workers refuse to service Aeroflot flights.

While no U.S. airlines currently fly into the Soviet Union, ALPA immediately began working with the International Federation of Air Line Pilots Associations, which represent some 53,000 commercial airline pilots in 67 countries, to implement our recommendation.

Our recommendations were: First, to declare the U.S.S.R. to be an offending state under IFALPA's air safety policy, for committing an attack on a civil airliner; and, second, to call for a ban on all flights to Moscow for 60 days, with a review at the end of 30 days to include consideration of a possible extension of that ban if the Soviets have not taken sufficient action.

This ban, which began September 12, is being observed by pilots in England, Norway, Denmark, Sweden, France, the Netherlands, Italy, Spain, Switzerland, and Finland.

Now, on the technical side, as you are aware, technology has vastly improved the safety and operational effectiveness of long-range overwater navigation systems. We no longer have the navigator with his sextant, loran-A has been discontinued, and the Doppler is rapidly being phased out. These once heavily used systems have been replaced by the OMEGA and the inertial navigation system, which are used almost exclusively on the world's major air carriers today.

To gain an appreciation of the accuracy and reliability of these two navigation systems, one need only look at the complexity of the North Atlantic track system, the world's busiest organized route structure. Because of capabilities and sustained performance of OMEGA and INS, the amount of air traffic has been able to virtually double within the confines of this route structure, with a level of safety and economy of operation that was not possible with previously used navigation systems.

In other organized track systems, such as the one between the west coast and Hawaii, and the North Pacific routes from North America to the Far East, equal economic and operational benefits have been realized because of OMEGA and INS. I assure you, pilot confidence in these systems is high or they would not participate in operations involving a significant reduction in normal oceanic separation standards.

Having made this statement, Mr. Chairman, I do not want to leave you with the impression that long-range overwater navigation is a troublefree, "no sweat" process. To the contrary, the navigation systems used are subject to the same failures and malfunctions as other systems aboard today's complex aircraft.

I believe if you ask the Federal Aviation Administration for a list of system deficiency reports relating to OMEGA and INS, you will find that, while minimal, they do occur.

The thing that keeps such failures from becoming catastrophic events is the required redundancy of such equipment. Operational specifications issued by the FAA require that duplicate systems be carried aboard all air carrier aircraft. Most companies voluntarily exceed this requirement and carry three sytems, which in some cases are combinations of both INS and OMEGA.

While these comments speak to the reliability of the equipment, the other part of the navigation equation that must be addressed is the human responsibility for monitoring its performance, specifically the pilot.

Flightcrew members participating in international long-haul operations are subject to interruptions of their "Circadian rhythm." In our business that's commonly called flying on the back side of the clock. Any person working shift work can testify to the problems associated with requiring one's body to deviate from a long-standing pattern of behavior. Experts have written a great deal on this subject, and flightcrews are not exempt from the characteristics of this phenomenon. It usually manifests itself through simple monitoring errors, rather than gross performance errors. Thus, spending several hours in a cockpit in a monitoring role while fatigued sets the stage for errors.

I am sure many people read the article in the September 11 issue of the Washington Post relating to pilots making mistakes in programing on-board navigation computers. This does happen, and in the majority of cases can be directly attributed to the human factors problems associated with long-haul international flights. While modern science may never be able to resolve this problem, its impact can be mitigated through proper crew sizing, good operating techniques, and crew discipline.

The same Washington Post article I referred to also contained the following statement—and I quote:

> Automation on new-technology airplanes is creating some gnawing questions for safety experts. Should everything possible be computerized? What are the human consequences? The problems are particularly acute on long, overwater international flights that are far from civilian radar surveillance and where the airline crew members have to rely completely on their own skills, their ability to work together, and their equipment.

This is a very challenging statement, Mr. Chairman, and one I hope the responsible officials will consider very thoroughly before authorizing a twin-engine aircraft with a two-member crew to participate in long-distance, overwater flights.

Mr. Chairman, while we are satisfied with today's long-range navigation systems, obviously there is always room for improvement. It would seem that today's technology would allow the development of a system that could relay periodic INS position information from aircraft on oceanic routes via satellite to oceanic control centers, thus providing an independent verification of pilot position reports.

Additionally, the civil sector must continue to explore the possible benefits of military systems such as GPS and the over-the-horizon backscatter radar. Both appear to have great potential.

The Radio Technical Commission for Aeronautics is now in the process of establishing a special committee to examine the communications, navigation, and surveillance requirements of aviation for the future. We look forward to participating in that activity.

Today, we don't know if system or navigational failure were to blame for KAL 7 being off course—and we may never know. No matter what the reason, we can never let it obscure the fact that the Russians shot down an unarmed commercial airliner and we can think of no motivation whatsoever that would justify such an action. The international intercept procedures were established in contemplation that aircraft would go off course. We must take every action that will force the Soviet Union to abide by the rules of civil air commerce.

That concludes my statement, Mr. Chairman.

Mr. GLICKMAN. Thank you, Captain Duffy, and I appreciate your final comments that one of the overlooked issues in the Korean Air Line crash is the jeopardy that it places to the survival of a free and dynamic civil aviation system in the world. There has probably been nothing done in the world to change it more in the last 30 years as the freedom to fly, and that's one of the reasons why not only are we required to segregate the Russians—and the rest of the world is doing a fair job of doing that under our leadership, not quite as strong as I would like to see—but also to prevent it from happening from a technical point of view as well. So I think your statement is an excellent one.

I would just ask you, everybody talks about equipment redundancy. Can you describe for me what are the redundant things that will protect an airliner from going astray, equipmentwise?

Captain DUFFY. Of course, as we have discussed here today already, in this airplane, as we understand it, was a triple redundant system, so there are three systems checking each other on the INS by itself. As you have heard earlier this morning, a mapping radar, the weather radar, also has a mapping mode. It can also look down and take a look at the islands that are down there, the land masses. Those are all things that should cross-check.

In addition to that, and one of the strong recommendations that we're making here, is ground radar. You know, somebody ought to be looking at this thing from the ground, and if he sees him going off course, there ought to be positive communication there so that we've got, you know, not only somebody on the ground looking to see that the airplane is where it is, but, of course, the guy in the cockpit is looking at the airplane to see where it is.

Mr. GLICKMAN. Where could we station this ground radar, let's say, in the Far East, the Western Pacific? How could you improve the ground radar system we have there now? All we have, of course, is our Aleutian Island radar and the Japanese radar.

What can we do to put something in between?

Captain DUFFY. Well, there obviously has to be some coordination with existing defense radar. Defense radar has over-the-horizon capabilities, and that's what we need here. Now, I don't know if we need to put over-the-horizon civilian radar in or work out agreements with the defense radar so that there is a positive communication link, so that that airplane is tracked. If he's off track, a positive communications link back to the civilian authorities and then to the airplane.

Mr. GLICKMAN. OK. Now, let me ask you a few questions about this over-the-horizon radar—and I'm not going to get into questions about what did our military people see on their screens or not because I don't know—that's not the jurisdiction of this committee.

What is the capability of an over-the-horizon radar?

Captain DUFFY. Well, in this case we could have had positive radar contact with that airplane along its whole route of flight, had we had something in Japan looking back the other way and something on the Aleutians looking out the other way. We could have had a positive look at that airplane during its entire route along R-20 and, of course, when they seen him off, they could have called him and updated his information.

Mr. GLICKMAN. Just like it would have been done in the domestic territory of the United States.

Captain DUFFY. Absolutely.

And there was a question earlier by someone about well, what would happen if that took place in the United States? Well, somebody would have seen him immediately because we've got positive radar contact and would have told him that he was straying off course.

Mr. **Glickman**. Do you know why civilian authorities have not used the over-the-horizon radar up until now?

Captain **Duffy**. I don't know. I don't know if it that's a technological improvement that is still restricted to the Defense Department or if it's expense or what the reason is.

Mr. **Glickman**. OK. Well, the DOD will be here and perhaps they can comment on that.

But clearly what you're saying is that over-the-horizon radar has the capability to spot an aircraft in the distances that this airplane would have been from the actual radar equipment itself and would have perhaps contacted the pilot and alerted him as to his course deviation.

Captain **Duffy**. That's right, and the reason that's so important is—you know, of all the things I have heard here this morning, we keep getting back to the human factors. And one good cross-check on the human factors is to have somebody on the ground also looking at you. You know, we've got all of the redundancy including the human redundancy in the cockpit, but if all of that goes astray, if you have this external force out there also looking at it, you've got one more cross-check to stop this kind of error from happening.

Mr. **Glickman**. Thank you very much.

Mr. McCandless.

Mr. **McCandless**. Thank you, Mr. Chairman.

A lot of questions have been asked this morning about various aspects of the pilot compartment, what goes on there. How would you respond to a question that said something like this, that probably one of the biggest factors involved in flying long distances is the boredom that sets in? Is that——

Captain **Duffy**. I think that's accurate. I think, as you heard Captain Frisbie outline the different disciplines, that so much of the disciplines of flying is aimed at countering that boredom. It is in anticipation that you do have to program yourself to stay alert and to make sure that errors don't happen, and then the crew redundancy. I mean, where that discipline breaks down, errors take place. That's nothing new to aviation, but perhaps all the new technology is making it more and more difficult to contend with.

Mr. **McCandless**. So if you didn't have automatic pilots and you didn't have all these things, you would be busy all the time and you wouldn't have a chance to get bored?

Captain **Duffy**. Well, we would probably be so busy we wouldn't be able to fly so long, because there is fatigue that also comes with that. So what we constantly are working at in the way of crew duties is a level of activity that keeps you interested and keeps you involved, but not to the point where your wheels are running so fast that fatigue is going to set in after a number of hours.

Now, that, you know, there is a whole debate going on about how much computerization and how much we should automate. We've got reams of material that's being written about the subject of automation right now and we're struggling with it in this industry.

Mr. **McCandless**. There are many other jobs that take on certainly an important level of performance. One that we take for granted a lot of times until we're on the freeway and participating in this is the cross-country truck driver, who has to be alert all the time. He can't vary his course or anything like that on the highway. Yet he's in direct command of that and has to be directly active using that as a base point, that the pilot and other members of the crew have an opportunity to get up and stretch, walk around, get a cup of coffee, come back.

I'm wondering what you might suggest that would be relevant to this committee's jurisdiction that would reduce what we have come to know here in our brief term as boredom.

Captain DUFFY. Well, I think that first of all, as someone said earlier, you have to understand that in a great majority of the flights the crews have accommodated themselves to this and they operate fine. So what we need is a cross-check procedure to catch the crews that slip out of this.

I'm not sure that there is anything that you could ever design into the cockpit that is going to be absolute and 100 percent. I think the procedures, as I know them, in U.S. carriers are adequate. One of the problems here—and we have encountered it all morning—the speculation is we don't know the KAL procedures. So we would need to look, I think, at what the KAL procedures were and see if there is some correction there. But they may well have just as complex procedures as we do, and more, but we're really in the area of really pure speculation.

So the direct answer to your question, I think the procedures are adequate now because most of those flights operate—the great, overwhelming majority of those flights operate just fine. I would put a cross-check on the ground to catch the ones that don't.

Mr. MCCANDLESS. The flight from Los Angeles to Tokyo takes 11 to 12 hours. After the plane is airborne and you've cleared the coastal area, what usually happens in the cockpit? Does the captain say to the first officer, "You handle it for the next hour and I'll come back and relieve you," or is that something that varies so much that one couldn't say?

Captain DUFFY. No, I think as a generalization one person is in primary—you know, as you alternate legs between the captain and copilot—one person is in primary navigational control of the airplane, with the other cross-checking, and with the third guy looking in on all of that.

I think that, you know—Now, the degree to which you get up and stretch and move around the cockpit depends on the individual crews and where the captain is on that. But as a general rule, I think that there is one person in primary control with the other cross-checking.

And then you heard the procedures that Captain Frisbie outlined. There are some very specific and periodic two-crew involvement, and sometimes three-crew involvement, where you've got people cross-checking against the others. And then, in addition to all of that, you do have a relief crewmember on some flights, depending on their length, that would come in and allow one of the crewmembers to rest.

Mr. MCCANDLESS. Then if I could summarize for you, you're reasonably satisfied with what goes on in the American-based plane during its time traveling an overseas route.

Captain DUFFY. Oh, yes.

Mr. McCANDLESS. As far as the FAA's requirements, their rules, regulations, and those rules and regulations of the various U.S. based carriers?

Captain DUFFY. Yes. And, you know, along the lines that Captain Frisbie was talking about, there may be some increased reporting requirement around very, very sensitive areas as we get into on parts of R-20, but then, as he also said, when you're coming across the middle of the Pacific somewhere there isn't anything on either side, what we've got is perfectly adequate.

Mr. McCANDLESS. Thank you, Captain.

Thank you, Mr. Chairman.

Mr. GLICKMAN. I just want to follow up for a moment on one of Mr. McCandless' questions.

You indicated you did not know what KAL's operating procedures were for checking the INS systems, what their training systems were. Do you believe that ICAO ought to establish some international standards for pilots and for equipment on aircraft flying over the ocean?

Captain DUFFY. Oh, I think so. I was somewhat surprised, I guess, as we dug into this, to find out that there was not quite the preciseness there that we thought already existed. And so the ICAO standards that we heard may be a little more general than they should be, but——

Mr. GLICKMAN. You know, it reminds me, when the Administrator of the FAA wanted to go to this regulation by objective, which is basically "you shall operate your airplane safely" and then you come up with the methods of doing it, I think that's kind of what the ICAO standards are. It just strikes me that either ICAO does it or the FAA by regulation, indicates that any carrier that flies in our out of the United States shall meet the following standards. At a minimum, maybe they ought to do that anyway.

Captain DUFFY. Of course, trying to tie that to with what went on with KAL 007 is, since we don't know what in the world took it up there, because, you know, in hearing all the speculation that went on today, every time we come up with a theory we find two cross-checks that should have stopped it. So it's very difficult for us to find him up there within the equipment that was on board and what should have been in place. The only thing that we know that could have prevented something like that would have been somebody on the ground looking at him and telling him that he was off.

Mr. GLICKMAN. And, in fact, there was some discussion that there were some people on the ground but didn't really know what to do once they thought they might have seen somebody like that. So——

Captain DUFFY. That's where the positive communication requirement comes in.

Mr. GLICKMAN. Thank you. Oh, yes, one more question, Mr. McCandless.

Mr. McCANDLESS. I have a quick one, Captain Duffy.

Russian aircraft designers in the field of the military place great importance upon putting the main key controls in the same location, irrespective of the configuration of the plane. For example, the landing gear is always in a certain location. Other primary levers and controls are always in the same location.

Do you consider this to be anything of any consequence in commercial aviation, that all of these things should be in the same area and that the design of the aircraft should be standardized?

Captain DUFFY. I agree with all the comments you heard this morning. Standardization has always been the key to the safety end of our business, and it is a problem. It is a problem just the way it was explained this morning. If you are used to seeing the same switch in the same place on four out of the five airplanes you've got, and now you get in the fifth, it takes some special recognition to deal with that, and the problem is, as fatigue comes on, you are more likely to make a mistake because of that switch being in a different position. And so, you know, the fact that they buy their airplanes from different people and the switches are all assembled different is a very real factor on some airlines for the pilots to deal with.

Mr. McCANDLESS. Thank you.

Thank you, Mr. Chairman.

Mr. GLICKMAN. I appreciate very much your testimony and for your general help to this committee on a variety of issues.

Captain DUFFY. Fine. Thank you, Mr. Chairman.

[The prepared statement of Captain Duffy follows:]

Statement of
Captain Henry Duffy
President, Air Line Pilots Association

Before the
House Science and Technology
Subcommittee on Transportation,
Aviation and Materials,
U.S. House of Representatives
September 19, 1983
"Current Aircraft Navigation Technology"

Good morning, Mr. Chairman. I am Henry Duffy, President of the Air Line Pilots Association, which represents the professional interests of 34,000 pilots who fly for 47 airlines. With me is John O'Brien, Director of ALPA's Engineering and Air Safety Department. I appreciate the opportunity to appear before you today to present in a brief statement the views and efforts of the line pilot on the KAL 007 incident and on the long-range navigation systems used in today's air transportation system.

I can't say that I'm happy to be here, because the subject which brings us together is the loss of 269 human lives.

Because airline pilots bear the ultimate responsibility for the safety of their passengers, we seek actions that will guarantee the safety of civilian air passengers. If the Soviet Union wants to continue civil air commerce with the rest of the world, it must act civilly. That means obeying the spirit and the letter of the rules governing international air traffic. ALPA has taken an active role in seeking to force the Soviet Union to guarantee the safety of international airways.

Let me outline what we have done thus far:

Shortly after the facts of the downing of the Korean Air Lines 747 became known, the State Department asked ALPA and other aviation groups for suggested actions.

Our advice was -- and is -- that any actions that are taken be in the same arena as the provocation; namely, commercial air traffic.

We recommended that all flights to Moscow be banned and that free workers refuse to service Aeroflot flights.

While no U.S. airlines currently fly into the Soviet Union, ALPA immediately began working with the International Federation of the Air Line Pilots Associations, which represents some 53,000 commercial airline pilots in 67 countries, to implement our recommendation.

The recommendations were:

One, to declare the USSR to be an "offending state" under IFALPA's air safety policy, for committing an attack on a civil airliner; and

Two, call for a ban on all flights to Moscow for 60 days, with a review at the end of 30 days to include consideration of a possible extension of the ban if the Soviets have not taken sufficient action.

This ban, which began September 12, is being observed by pilots in England, Norway, Denmark, Sweden, France, the Netherlands, Italy, Spain, Switzerland, and Finland.

On the technical side, as you are aware, technology has vastly improved the safety and operational effectiveness of long-range overwater navigation. We no longer have the navigator with his sextant, LORAN "A" has been discontinued, and the Doppler is rapidly being phased out. These once heavily used systems have been replaced by the "OMEGA" and the "inertial navigation system" (INS), which are used almost exclusively on the world's major air carriers today.

To gain an appreciation of the accuracy and reliability of these two navigation systems, one need only look at the complexity of the North Atlantic Track System, the world's busiest organized route structure. Because of capabilities and sustained performance of Omega and INS, the amount of air traffic has been able to virtually double within the confines of this route structure, with a level of safety and economy of operation that was not possible with previously used navigation systems. In other organized track systems, such as the one between the West Coast and Hawaii, and the North Pacific routes from North America to the Far East, equal economic and operational benefits have been realized because of Omega and INS. I assure you, pilot confidence in these systems is high or they would not participate in operations involving a significant reduction in normal oceanic separation standards.

Having made this statement, Mr. Chairman, I do not want to leave you with the impression that long-range overwater navigation is a troublefree, "no sweat" process! To the contrary, the navigation systems used are subject to the same failures and malfunctions as other systems aboard today's complex aircraft. I believe if you ask the Federal Aviation Administration for a list of system deficiency reports relating to Omega and INS, you will find that, while minimal, they do occur! The thing that keeps such failures from becoming catastrophic events is the required redundancy of such equipment. Operational specifications issued by the FAA require that duplicate systems be carried aboard all air carrier aircraft. Most companies voluntarily exceed this requirement and carry three systems, which, in some cases, are combinations of both INS and Omega. While these comments speak to the reliability of the equipment, the other part of the navigation equation that must be addressed is the human responsible for monitoring its performance, specifically the pilot.

Flight crew members participating in international long-haul operations are subject to interruptions of their "circadian rhythm," more commonly known as "working on the back side of the clock." Any person working shift work can testify to the problems associated with requiring one's body to deviate from a long-standing pattern of behavior. Experts have written a great deal on this subject, and flight crews are not exempt from the characteristics of this phenomenon. It usually manifests itself through simple monitoring errors, rather than gross performance errors; thus, spending several hours in a cockpit in a "monitoring role" while fatigued sets the stage for errors. I am sure many people read the article in the September 11 issue of the Washington Post relating to pilots making mistakes in programming on-board navigation computers. This does happen, and in the majority of cases can be directly attributed to the human factors problems associated with long-haul international flights. While modern science may never be able to resolve this problem, its impact can be mitigated through proper crew sizing, good operating procedures, and crew discipline. The same Washington Post article I referred to also contained the following statement, and I quote:

> Automation on new-technology airplanes is creating some gnawing questions for safety experts. Should everything possible be computerized? What are the human consequences? The problems are particularly acute on long, overwater

> international flights that are far from civilian radar surveillance and where the airline crew members have to rely completely on their own skills, their ability to work together, and their equipment.

This is a very challenging comment, Mr. Chairman, and one I hope the responsible officials will consider very thoroughly before authorizing a twin-engine aircraft with a two-member crew to participate in long-distance, overwater flights.

Mr. Chairman, while we are satisfied with today's long-range navigation systems, obviously there is always room for improvement. It would seem that today's technology would allow the development of a system that could relay periodic INS position information from aircraft on oceanic routes, via satellite, to oceanic control centers, thus providing an independent verification of pilot position reports. Additionally, the civil sector must continue to explore the possible benefits of military systems such as GPS and the "over-the-horizon-backscatter radar." Both appear to have great potential. The Radio Technical Commission for Aeronautics is now in the process of establishing a special committee to examine the communications, navigation, and surveillance requirements of aviation for the future. We look forward to participating in that activity.

Today, we don't know if system or navigational failure were to blame -- and we may never know. No matter what the reason, we must never let it obscure the fact that the Russians shot down an unarmed commercial airliner and we can think of no motivation whatsoever that would justify such an action. The international intercept procedures were established in contemplation that aircraft would go off course. We must take every action that will force the Soviet Union to abide by the rules of civil air commerce.

Mr. Chairman, this concludes my remarks. I would be most happy to answer any questions you may have.

Mr. **Glickman**. We have two more witnesses. We have Loren De Groot, director, avionics systems, at Rockwell, International, who will I think talk about a variety of satellite and GPS issues, and finally we have the Honorable Donald Latham, Deputy Under Secretary of Defense. Then that will end the hearings.

So our next-to-the-last witness is Mr. De Groot, director of avionics with Rockwell. I think you have some video displays here, too, if I'm not mistaken.

Mr. **De Groot**. Yes, sir.

Mr. **Glickman**. It's a pleasure to have you here. Why don't you go ahead and proceed.

STATEMENT OF LOREN E. DE GROOT, DIRECTOR, AVIONICS SYSTEMS, ROCKWELL, INTERNATIONAL

Mr. **De Groot**. Thank you, Mr. Chairman.

We have heard several times in testimony before this committee this morning mention of the GPS. I wish to thank you and the other members of this committee for the opportunity to discuss what I consider to be an exciting and really revolutionary navigation system—the Navstar global positioning system.

Beginning in 1978, some new stars were placed in orbit 11,000 miles above the earth. These Navstar satellites are transmitting signals that provide a user with three-dimensional navigational information. When the GPS system is fully operational in 1988, it will consist of a network of satellites and thousands of individual user sets. Benefits to be derived from this new navigation technology include a savings in energy, money, and lives.

Although GPS is being developed by the Department of Defense, the system offers far-reaching benefits to the civilian community. Anyone needing precise position, velocity and time information can put this space-based system to work.

Recently we equipped a Sabreliner business jet aircraft with a GPS navigation receiver and flew it from Cedar Rapids, Iowa, to Paris, France. This flight demonstrated that GPS is here today and that it can be flown in today's air traffic control environment. Subsequent to that flight, we prepared a short documentary video tape that I believe you will find informative. If we could have the tape now, please.

[Video tape presentation follows:]

NAVSTAR ONE CROSSES THE ATLANTIC
(TEXT OF VIDEO TAPE)

"NAVSTAR ONE: You're cleared for take-off."

With that clearance on May 22, 1983, another record flight in the history of aviation began. Unlike any aircraft before it, a Rockwell Sabreliner business jet navigated from the heartland of American to Paris, France, using NAVSTAR satellites. While navigators have been using the stars for centuries, no navigator had ever before used a man-made star to navigate an aircraft across the Atlantic. With this historic flight to the 1983 Paris Air Show, the NAVSTAR Global Positioning System came a step closer to worldwide availability for civil users such as commercial aviation.

GPS has both surface and air applications because of its exceptional accuracy in determining position, velocity and time. It delivers three-dimensional position information with a typical accuracy of sixteen meters ... velocity information to the nearest one-tenth of a meter-per-second ... and the correct time to within one-billionth of a second.

The NAVSTAR Global Positioning System provides precise accuracy because the system has three key elements: First, the planned satellite constellation in space that will provide global two-dimensional coverage by 1987 and global three-dimensional coverage by 1988. Second, the ground control stations that transmit corrected satellite position and time data to the satellites. And third, the user sets which receive the satellite signals and calculate user position, velocity and time.

To demonstrate the capability of GPS for civil aircraft applications, two GPS receivers and control displays were installed in a specially-designed rack in the passenger compartment for the flight of Navstar One. The co-pilot's Horizontal Situation Indicator was wired to display GPS-derived guidance information. The GPS antenna replaced one of the aircraft's existing antennas. After turning the system on, the receiver automatically located and tracked the NAVSTAR satellites in less than five minutes. The system identified the satellite number, located the satellite in space and established system time. Navstar One's GPS receivers processed signals from four satellites which instantaneously determined the aircraft's latitude, longitude, and altitude. The GPS space segment, when fully operational in 1988, will be comprised of eighteen satellites. With this satellite constellation, an aircraft will be able to locate itself anywhere in the world, twenty-four hours a day.

By making the historic transatlantic crossing, Navstar One demonstrated GPS's practicality for civil aviation applications as well as its global accuracy. GPS was used exclusively to guide the aircraft throughout its flight although other navigation systems such as inertial and Omega were installed on the aircraft.

To accommodate the presently limited signal coverage, Navstar One made its way to the Paris Air Show via five separate flight segments. Starting in Cedar Rapids, Iowa, Navstar One stopped in Burlington, Vermont; Gander, Newfoundland; Reykjavik, Iceland; and London, England, before landing at LeBourget Airport near Paris. In making this trip a number of National Aeronautic Association records were made as were three World aviation records.

Upon arrival at the Le Bourget-Paris Airport, the aircraft taxied along assigned taxiways defined in GPS coordinates with satellite guidance. When the aircraft stopped it was only twenty-five feet from the designated parking place.

The flight of Navstar One demonstrated a significant technological advance in navigation by illustrating the practicality of the Navstar Global Positioning System in the civilian air traffic control environment. GPS was used to independently and continuously establish the position of Navstar One ... minimizing aircrew workload and the possibility of human error.

The flight of Navstar One demonstrated the viability of the Global Positioning System for civilian aviation applications. It was a flight that not only set new aviation records as Navstar One crossed the Atlantic for the first time ... but it also brought the Navstar Global Positioning System one step closer to worldwide use.

Mr. De Groot. While the flight of Navstar One demonstrated the viability of the global positioning system for civil aviation applications, several factors preclude its immediate adoption by this community. I would like to address some of the more critical issues with you this morning.

Safety of flight considerations, as we have heard, dictate that the aviation community be sensitive to the many requirements that are imposed upon it. The last thing that is needed is the imposition of a requirement that is ill-founded or superfluous. However, the recent tragedy of KAL 007 suggests that we once again consider the advantages to be gained from automatic surveillance of aircraft when they are out of range of land-based radar. Long-range surveillance requires two basic capabilities to be present on board the aircraft; independent position monitoring and automatic, reliable long-range communications with air traffic control centers.

GPS can provide the independent position monitoring function. In its fully operational configuration, GPS will provide a 24-hour, day/night all-weather positioning capability in a common coordinate reference system for equipped aircraft. Further, GPS is the only system that can independently establish an unambiguous aircraft position without human intervention. Other navigation systems available today do not possess all of these desirable attributes. GPS, however, has the additional capability for growth to meet future separation assurance requirements.

Automatic, reliable long-range communications with air traffic control centers need to be expanded and improved. The emphasis in this statement is on the automatic aspect of long-range ATC communications. The improved capability of long-range surveillance—independent position monitoring and automatic, reliable long-range communications—could prove to be instrumental in preventing a recurrence of the KAL 007 tragedy.

Another issue I see is the concurrency of satellite availability and civil aviation GPS receivers. Present schedules call for the GPS system to provide a two-dimensional worldwide capability in 1987 and a three-dimensional positioning capability in 1988. The recent award of a multiyear, fixed price contract for production satellites insures that this schedule will be met. Planning, therefore, can proceed on a firm basis that GPS signals in space will be available in that timeframe.

The critical path for early implementation of GPS for civil aviation will not be the satellites, but, rather, the civilian receiver equipment. Although equipment designed to meet military requirements could be provided in the immediate timeframe, the civil aviation community historically has desired their own configurations. Serious work in the development of civil aviation receivers has, to the best of my knowledge, been funded exclusively by individual manufacturers. The civilian GPS equipment we flew to Paris on Navstar One was an engineering model that was built with company discretionary funds. But, before it can be utilized in certified civil aviation service, the design must be productionized and qualified to tough FAA specifications.

Typically, 1 to 2 years will be required to bring the engineering design of a civil navigation receiver such as GPS to a production-ready status. An additional year will be required before production quantities of the equipment could be available to the operational user. As you can see, we are only a lead time away from civilian aviation receiver availability if GPS is to be utilized by the civil aviation community when the satellites become operational.

The final issue I will address this morning relates to a direct user tax that could be imposed upon civilian users of the global positioning system. Following direction by the joint conference committee on the 1982 authorization bill, the Department of Defense announced a policy to recoup as much of the development, acquisition and operating costs of the GPS system as possible. This policy has served as a severe deterrent to acceptance of GPS by the total civilian community, including those in aviation.

I would urge the Congress to reconsider their earlier position on this matter, and to take affirmative action to eliminate consideration of user charges for civilian operators of GPS. Just as lighthouses are a national resource, so, too, are Navstar satellites.

Gentlemen, in summary, I believe that all the necessary elements of a solution to the types of problems faced by KAL 007 are available. Properly implemented, these solutions could preclude a recurrence of that tragic event.

The Navstar global positioning system has been developed by the United States under the direction of the Department of Defense. Although it was designed to meet military requirements, it can be utilized without change by the entire civilian community for the benefit of mankind. Satellites for this navigation system are now being procured under a firm fixed price production contract. Technologies necessary to produce low-cost, civil aviation receivers are well understood. And, we are able to define and implement an automatic, long-range data reporting system. The only action that is required is for the Government to facilitate this solution with timely policies and regulations that will bring about its implementation.

Thank you.

[The prepared statement of Loren De Groot follows:]

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ROCKWELL INTERNATIONAL
COLLINS GOVERNMENT AVIONICS DIVISION
CEDAR RAPIDS, IOWA

STATEMENT BY
MR. LOREN E. DE GROOT
DIRECTOR, AVIONICS SYSTEMS

BEFORE
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIEL
SCIENCE & TECHNOLOGY COMMITTEE
HOUSE OF REPRESENTATIVES

SEPTEMBER 19, 1983

NOT FOR PUBLICATION UNTIL RELEASED
BY THE SUBCOMMITTEE ON TRANSPORTATION,
AVIATION AND MATERIEL
HOUSE OF REPRESENTATIVES

BIOGRAPHY

LOREN E. DE GROOT
ROCKWELL INTERNATIONAL

LOREN E. DE GROOT is Director of Avionic Systems for the Collins Government Avionics Division of Rockwell International. Mr. DeGroot has been program manager for the design, development and testing of Phase I GPS generalized development model user equipments, and also directed Collins Phase II pre-design studies and full scale development activity. He received engineering degrees from the University of Michigan and is a past president of the United States Institute of Navigation. He was a navigator on both the 1965 Rockwell Polar Flight, which set eight world aviation records by flying around the world over both Poles, and the recent flight Navstar One, which set both national and world aviation records by flying a GPS-equipped business set to Paris, France. Prior to working for Collins, Mr. DeGroot held engineering and marketing management positions with other major electronics manufacturers.

STATEMENT BY
LOREN E. DE GROOT
DIRECTOR, AVIONICS SYSTEMS
COLLINS GOVERNMENT AVIONICS DIVISION
ROCKWELL INTERNATIONAL
TO
SUBCOMMITTEE ON TRANSPORTATION, AVIATION & MATERIEL
SCIENCE & TECHNOLOGY COMMITTEE
HOUSE OF REPRESENTATIVES

Good morning. Thank you for the opportunity to discuss with you what I consider to be a revolutionary navigation system . . . the NAVSTAR Global Positioning System.

Beginning in 1978, some new stars were placed in orbit 11,000 miles above the earth. These NAVSTAR satellites are transmitting signals that provide a user with three-dimensional navigational information. When the GPS system is fully operational in 1988, it will consist of a network of satellites and thousands of individual user equipment receivers. Benefits to be derived from this new navigation technology include a savings in energy, money and lives.

Although GPS is being developed by the Department of Defense, the system offers far reaching benefits to the civilian community. Anyone needing precise position, velocity and time information can put this space-based navigation system to work.

Recently, we equipped a Sabreliner business jet aircraft with a GPS navigation receiver and flew it from Cedar Rapids, Iowa to Paris, France. This flight demonstrated that GPS is here today and that it can be flown in today's air traffic control environment. Subsequent to that flight, we prepared a short documentary video tape that I believe you will find informative.

NAVSTAR ONE CROSSES THE ATLANTIC
(TEXT OF VIDEO TAPE)

"NAVSTAR ONE: You're cleared for take-off."

With that clearance on May 22, 1983, another record flight in the history of aviation began. Unlike any aircraft before it, a Rockwell Sabreliner business jet navigated from the heartland of American to Paris, France, using NAVSTAR satellites. While navigators have been using the stars for centuries, no navigator had ever before used a man-made star to navigate an aircraft across the Atlantic. With this historic flight to the 1983 Paris Air Show, the NAVSTAR Global Positioning System came a step closer to worldwide availability for civil users such as commercial aviation.

GPS has both surface and air applications because of its exceptional accuracy in determining position, velocity and time. It delivers three-dimensional position information with a typical accuracy of sixteen meters ... velocity information to the nearest one-tenth of

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a meter-per-second ... and the correct time to within one-billionth of a second.

The NAVSTAR Global Positioning System provides precise accuracy because the system has three key elements: First, the planned satellite constellation in space that will provide global two-dimensional coverage by 1987 and global three-dimensional coverage by 1988. Second, the ground control stations that transmit corrected satellite position and time data to the satellites. And third, the user sets which receive the satellite signals and calculate user position, velocity and time.

To demonstrate the capability of GPS for civil aircraft applications, two GPS receivers and control displays were installed in a specially-designed rack in the passenger compartment for the flight of Navstar One. The co-pilot's Horizontal Situation Indicator was wired to display GPS-derived guidance information. The GPS antenna replaced one of the aircraft's existing antennas. After turning the system on, the receiver automatically located and tracked the NAVSTAR satellites in less than five minutes. The system identified the satellite number, located the satellite in space and established system time. Navstar One's GPS receivers processed signals from four satellites which instantaneously determined the aircraft's latitude, longitude, and altitude. The GPS space segment, when fully operational in 1988, will be comprised of eighteen satellites. With this satellite constellation, an aircraft will be able to locate itself anywhere in the world, twenty-four hours a day.

By making the historic transatlantic crossing, Navstar One demonstrated GPS's practicality for civil aviation applications as well as its global accuracy. GPS was used exclusively to guide the aircraft throughout its flight although other navigation systems such as inertial and Omega were installed on the aircraft.

To accommodate the presently limited signal coverage, Navstar One made its way to the Paris Air Show via five separate flight segments. Starting in Cedar Rapids, Iowa, Navstar One stopped in Burlington, Vermont; Gander, Newfoundland; Reykjavik, Iceland; and London, England, before landing at LeBourget Airport near Paris. In making this trip a number of National Aeronautic Association records were made as were three World aviation records.

Upon arrival at the Le Bourget-Paris Airport, the aircraft taxied along assigned taxiways defined in GPS coordinates with satellite guidance. When the aircraft stopped it was only twenty-five feet from the designated parking place.

The flight of Navstar One demonstrated a significant technological advance in navigation by illustrating the practicality of the Navstar Global Positioning System in the civilian air traffic control environment. GPS was used to independently and continuously establish the position of Navstar One ... minimizing aircrew workload and the possibility of human error.

> The flight of Navstar One demonstrated the viability of the Global Positioning System for civilian aviation applications. It was a flight that not only set new aviation records as Navstar One crossed the Atlantic for the first time ... but it also brought the Navstar Global Positioning System one step closer to worldwide use.

END OF VIDEO TAPE TEXT

While the flight of Navstar One demonstrated the viability of the Global Positioning System for civil aviation applications, several factors preclude its immediate adoption by this community. I would like to address some of the more critical issues for a few minutes this morning.

Safety of flight considerations dictate that the aviation community be sensitive to the many requirements that are imposed upon it. The last thing that is needed is the imposition of a requirement that is ill-founded or superfluous. However, the recent tragedy of KAL 007 suggests that we once again consider the advantages to be gained from automatic surveillance of aircraft when they are out of range of land-based radar. Long-range surveillance requires two basic capabilities to be present on board the aircraft: Independent position monitoring and automatic, reliable long-range communications with air traffic control centers.

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Automatic, reliable long-range communications with air traffic control centers need to be expanded and improved. The emphasis in this statement is on the automatic aspect of long-range ATC communications. The improved capability of long-range surveillance, independent position monitoring and automatic, reliable long-range communications, could prove to be instrumental in preventing a recurrence of the KAL 007 tragedy.

Another issue I see is the concurrency of satellite availability and civil aviation GPS receivers. Present schedules call for the GPS system to provide a two-dimensional worldwide capability in 1987 and a three-dimensional positioning capability in 1988. The recent award of a multi-year, fixed price contract for production satellites ensures that this schedule will be met. Planning, therefore, can proceed on a firm basis that GPS "signals in space" will be available in the stated timeframe.

The critical path for early implementaion of GPS for civil aviation will not be the satellites, but, rather the civilian receiver equipment. Although equipment designed to meet military requirements could be provided in the immediate timeframe, the civil aviation community historically has desired their own configurations. Serious work in the development of civil aviation receivers has to the best of my knowledge, been funded exclusively by individual manufacturers. The civilian GPS equipment we flew to Paris on Navstar One was an engineering model that was built with company discretionary funds. But, before it can be utilized in certified civil aviation service, the design must be productionized and qualified to tough FAA specifications.

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The final issue that I will address this morning relates to a direct user tax that could be imposed upon civilian users of the Global Positioning System. Following direction by the Joint Conference Committee on the 1982 Authorization Bill, the Department of Defense announced a policy to recoup as much of the development, acquisition and operating costs of the GPS system as possible. This policy has served as a severe deterrent to acceptance of GPS by the total civilian community including those in aviation.

I would urge the Congress to reconsider their earlier position on this matter, and to take affirmative action to eliminate consideration of user charges for civilian operators of GPS. Just as lighthouses are a national resource, so too, are NAVSTAR satellites.

Gentlemen, in summary, I believe that all the necessary elements of a solution to the types of problems faced by KAL 007 are available. Properly implemented, these solutions could preclude a recurrence of that tragic event.

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Mr. GLICKMAN. Thank you for your testimony.

One of the witnesses before testified that if locations, coordinates, are improperly entered, it wouldn't matter whether you were using a GPS or an INS system; that is, so to speak, "garbage in, garbage out." I wonder if you might comment on that, specifically what advantage a GPS system would have over an INS system, particularly if improper coordinates were entered in.

Mr. DE GROOT. If GPS were being used to guide the airplane, and the derivation of guidance information was based on GPS, you would have the same problem that was mentioned earlier. However, as I have suggested, GPS can provide a slightly different role, that is, one of independent position monitoring, establishing the position of the aircraft independent of the existing guidance.

If I know precisely where the aircraft is at all times, I don't care what the guidance information is. It is that function that GPS can provide as nonambiguous and worldwide navigation.

Mr. GLICKMAN. So you could use it as, so to speak, a finder of the airplane, irrespective of its navigational role, then, or you could use it for both roles?

Mr. DE GROOT. Yes. Earlier testimony indicated the use of over-the-horizon radars. That is a separation of the determination of position, an assurance that you have two different schemes available to find the aircraft. GPS could be one of those alternative schemes, whereby the guidance of the aircraft was not predicated upon the GPS.

Now, if that is a system which were to be implemented, human intervention would not be required. GPS is initialized by turning the system on and initiating the present position and time. If a wrong time or a wrong position is inserted, the system will automatically reject that but will use it as a starting point to determine the actual position. The system does not require human intervention for its operation.

Mr. GLICKMAN. What are we talking about in terms of costs of a system like this?

Mr. DE GROOT. When we consider the cost of a navigation system, there are always many things that have to be stated and qualification placed on it. By comparison, we have heard this morning about inertial navigation systems. Today, depending on the system configuration—that is, whether it's a sensor or a full-up navigation system—an inertial system, the initial procurement cost will vary between $75- and even upward of $100,000.

Mr. GLICKMAN. Per airplane?

Mr. DE GROOT. Per system.

Mr. GLICKMAN. Per system. OK.

Mr. DE GROOT. If you have three onboard, it's three times that, obviously. So anywhere from a quarter-of-a-million to a half-million dollars could be expended on inertial navigation systems for a given long-range aircraft.

We believe the GPS, in a sensor configuration, can be procured in the timeframe that we're talking about, 1987–88, for approximately $10,000.

One other aspect of system cost that is necessary to consider is what we refer to as the operating costs; the maintenance and operation of the system. Inertial systems are very complex. They require a lot of expensive maintenance when something goes broke on them. I have heard numbers as high as $10,000 to $15,000 a year per inertial system as the annual repair charge. The GPS equipment, receiver equipment, is really very simple. It is simply a radio receiver with a computer tied to it. Our studies so far indicate that the support costs will be less than $500 per year.

Mr. GLICKMAN. OK. Again, I want to clarify. If we're talking about its use as a sensor-related use, you would still be talking about GPS with an existing navigational system; that is, the airplane would retain its INS system then; is that correct?

Mr. DE GROOT. Yes.

Mr. GLICKMAN. It would just be an almost fool-proof cross-check, if properly utilized by ground controllers somewhere.

Mr. DE GROOT. The question we're addressing is what can be done to prevent the recurrence of the KAL. In that sense, GPS, as an independent position monitor, could provide that function. From that starting point, since GPS obviously has a worldwide capability of accuracies far greater than those provided by anything else, there is a natural progression to make that the prime navigation system and to use other systems as backup.

Mr. GLICKMAN. OK. Thank you.

Mr. McCandless.

Mr. MCCANDLESS. Thank you, Mr. Chairman.

Mr. De Groot, you spoke on page 7 of the fact that you hope Congress will reconsider their position about the user fee. Then we talked about the cost of the system in question and the cost of the existing system and how, if the one replaced the other, the initial cost and maintenance cost would be substantially less.

In view of the substantially less costs for both the original procurement and for maintenance, it would appear to me that this would be something the commercial aviation industry would be delighted to participate in, since their cost per mile, cost per initial investment, would be far less, and the maintenance correspondingly so.

Why would you want us to reconsider our position in view of that?

Mr. DE GROOT. I'm not the expert to answer that question. However, I have information from the user community, which is the community to which that question should be addressed.

My belief is that the entire civilian community, in general, is opposed to direct tax or direct user charges on a given system. And the reason is one of the uncertainty of the future. If a system has a user charge today, and it is legislated to be $370, let's say, which is that figure which has been proposed for the standard positioning service of GPS, there is a great hesitancy and a concern as to what those charges will be in future years.

The airlines, particularly, general aviation operators more specifically, are very concerned about operating costs. And if they have in their equation of business a factor which they cannot control, they are reluctant to endorse it. There has been, without any doubt, a deterrent which has been exhibited in the civilian community—aviation being only one of those communities—in which operators and users have said: "I will not consider GPS; I'm doing the job all right now; yes, I could get a better use of it, but I will not open myself to the danger of escalating user taxes."

They view the user charges in the same way as user charges on the interstate highway system. It is a national resource. The beneficiary of the system is the entire public, not just the individual user.

Mr. MCCANDLESS. Thank you. I have no further questions, Mr. Chairman.

Mr. GLICKMAN. Thank you for your testimony today. We appreciate it very much.

Our final witness today is the Honorable Donald Latham, Deputy Under Secretary of Defense for Command, Control, Communications, and Intelligence. We are glad that you could take the time to be here.

Mr. LATHAM. Yes, sir.

Mr. GLICKMAN. Hopefully we haven't inconvenienced you with the length of the hearings, and why don't you go ahead and proceed.

STATEMENT OF HON. DONALD C. LATHAM, DEPUTY UNDER SECRETARY OF DEFENSE FOR COMMUNICATIONS, COMMAND, CONTROL, AND INTELLIGENCE

Mr. LATHAM. Yes, sir.

As you may have noted, I have a brief statement for the record that I would ask you might include in the record. It is devoted almost exclusively to the global positioning system, and since you have heard a great deal about that, perhaps the easiest thing is just to proceed to any questions you might have of me on that or any other related subject.

Mr. **Glickman**. OK. I think that that's useful, and your entire statement will appear in the record for the purposes of these hearings.

[The prepared statement of Donald Latham follows:]

UNCLASSIFIED

STATEMENT FOR THE RECORD

BY

DONALD C. LATHAM

DEPUTY UNDER SECRETARY OF DEFENSE

(COMMUNICATIONS, COMMAND, CONTROL

AND INTELLIGENCE)

BEFORE THE

HOUSE SCIENCE & TECHNOLOGY COMMITTEE

SUBCOMMITTEE ON

TRANSPORTATION, AVIATION & MATERIALS

MONDAY, 19 SEPTEMBER 1983

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STATEMENT FOR THE RECORD

DoD Radionavigation Systems

The NAVSTAR Global Positioning System

Thank you for this opportunity to briefly overview the Department of Defense (DoD) views on radionavigation and the NAVSTAR Global Positioning System (GPS) in particular. The GPS is a new and unique capability which will have a dramatic impact on our ability to conduct military operations. Further, the GPS will greatly benefit the civil sector across a wide spectrum of potential applications of which enroute aircraft navigation is but one such use.

The GPS is a space-based radionavigation system being developed under U.S. Air Force management. When fully deployed in 1988, this new system will continuously provide highly accurate position and velocity information in three dimensions, plus precise time on a global basis to an unlimited number of users equipped with GPS receivers. Weather is not a factor in system operation or performance. With GPS we can provide 24 hour per day, global navigation and position information to military users to an accuracy of tens of feet in three dimensions and velocity to an accuracy of about one-tenth of a meter per second. Time can be determined to an accuracy of 100 ~~m~~billionths of a second. This makes GPS at least ten times more accurate than any other radionavigation system. For civil users the GPS will provide positional information on a global basis, 24 hours per day to an accuracy of approximately 300 feet in two dimensions and velocity and time to an accuracy only slightly degraded from the military capabilities noted earlier.

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While the somewhat lower accuracy civil capability of GPS is not usable for precision airfield approaches, it is more than sufficiently accurate for enroute navigation and it is in that role that we would expect to see the commercial airlines use GPS.

Within the DoD we have been developing the necessary receive terminals for application to all the Services' requirements. The GPS receive terminals vary from a small manpack to terminals for aircraft carriers, submarines, and a variety of aircraft to include high performance fighters. Prototype user equipment is in test and performing extremely well using the six R&D GPS satellites which are currently on orbit. Our current projection is that in excess of 20,000 user terminals will be procured for U.S. military applications.

The space and ground control segments of GPS are in full scale development, and a firm fixed price multi-year production contract has been signed with Rockwell-Collins for the first buy of 28 satellites. The ground control segment is being developed by IBM Federal Systems Division. Satellite launches are planned to provide a global two-dimensional capability by late 1987 and a full three-dimensional capability by late 1988. The 18 operative satellites will be deployed in several different planes in space at an operating altitude of approximately 11,000 miles. Design features have been incorporated to ensure extremely high system reliability and survival to include jam-resistance in the user equipment. We will, for example, store on orbit spare GPS satellites so that we can rapidly replace a satellite if that should be required.

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In full partnership with the FAA we are jointly updating the Federal Radionavigation Plan for submittal this year to the Congress. That plan will detail the phase-in plan for GPS and quite importantly, the phase-out plan for other radionavigation systems which GPS will replace over time. It is our estimate that real savings to DoD in excess of $150M per year can be realized by this phase-out of the proliferation of existing radionavigation systems. This is not to say, however, that we will place all our eggs in the GPS basket, but rather that several other radionavigation systems can be safely turned off over time. Examples are TACAN, VOR/DME/VORTAC, OMEGA, TRANSIT and LORAN.

While this is only a brief and unclassified overview of the GPS, I believe the essential features have been covered. If there are any questions, I'll be glad to attempt to answer them. Thank you.

Mr. GLICKMAN. I thought maybe you might want to paraphrase for us where you think you are going with respect to the GPS program, how many satellites you're going to have on board and when it's going to be operative, and then also relate its role to the civilian sector.

Mr. LATHAM. Yes, sir, I would be very glad to do that.

We are under contract with the Rockwell Corp., as was just mentioned, for the first 28 satellites with a firm fixed price contract. That contract will allow us to have the system fully operational by late 1988. That means 18 operating satellites and probably at least three spare satellites on orbit for a total of 21 with the concept being that we would always have some spare satellites on orbit to replace any satellite that might malfunction. Thus we have extremely high system reliability built into the GPS concept.

The ground segment user equipment for the DOD is progressing quite well. In fact, the two different companies that are producing this equipment today are in test at a military facility and the equipment is moving along quite well and testing out quite well. This is equipment that will range from backpacks for the individual soldier to equipment that would go on aircraft carriers, submarines, or a variety of aircraft or helicopters.

Last, the ground control segment is under development and it's moving along well. We would thus see the system becoming operational, as I said, fully operational in 1988, two-dimensional capability in 1987. So that's moving.

As we have said, the system is intended for use by both military and civil users, as announced by our policy, and could be made available and, in fact, is being used by the civil community today. We have six satellites up today that are the early R&D satellites, and there are a number of GPS receivers that are in operation being used today for various purposes.

Mr. GLICKMAN. Could a communications package be added to the satellite, so you could use it to talk, communicate?

Mr. LATHAM. That has been studied, and the answer is yes. We could probably modify the GPS satellite such that it could also serve a dual role as a communications satellite, yes.

Mr. GLICKMAN. Now, is there any concern within the DOD, that if this system takes on a civilian function, that it would in any way impinge upon your use of GPS? And let me give you some background for that.

I have heard through the grapevine that there has been a reluctance, a reticence, on the part of the Defense Department to share this system, so to speak, with civilian users. I thought you might want to comment on that.

Mr. LATHAM. No, sir, I don't know of any reluctance. The way the system is designed, there are actually two signals that the satellite emits. One is a precision code and the other one is a standard positioning service. The military will use the precision code for its purposes. That particular signal from the satellite will be protected by an encryption device so that that signal is denied to adversaries. The civilian users would use the standard service, and that does not really impinge on the military use of the system, in that you can have an unlimited number of passive-receive users for the GPS system globally.

Mr. GLICKMAN. Where do we stand on the issue of user fees?

Mr. LATHAM. We stand under the gun from Congress in the 1982 authorization bill. Both the House and Senate side imposed on us—that we should have user charges, not only for the civil side but for non-DOD military. This would say that if we have a terminal, a GPS terminal in a United Kingdom aircraft somewhere, we somehow would charge for that terminal on some annual basis.

Frankly, as much time as I have spent on this, the problem of collecting user charges is mind-boggling. It's like selling license plates to the world. If you're going to sell it to the civil community, you have to put some sort of a device that would encrypt the signal also, protect it in some way, so that everybody just doesn't have free use of it. Then you would have to periodically change that device in order to keep the protection up. So it means that perhaps on an annual basis trying to sell somehow hundreds of thousands, potentially, civil protection devices to go into terminals all over the world. There is the issue of, if the terminal doesn't work, who's to blame, the protection device, the terminal, or something. And frankly, it's a very difficult, mind-boggling job to see how we, in the Department, are going to collect these user charges.

As the prior witness has noted, there is opposition to the user charges from the civil community, and on a political basis, it might be better all things considered that this is a service to the world that maybe we want to make available without having to impose these user charges.

But right now we are proceeding down the line that the Congress is going to continue to ask for these user charges.

Mr. GLICKMAN. OK. Well, we may get to work on that independently.

Mr. LATHAM. Yes, sir.

Mr. GLICKMAN. Let me ask you this. Are the Soviets building a GPS system, a satellite navigational system?

Mr. LATHAM. It appears that they are. They have released information on a Glonass, as it's called, a navigation system that would appear to have parameters from which they have released unclassified information on that and are extremely similar to the U.S. global positioning system. However, I believe their constellation of satellites would be somewhat less in number.

Mr. GLICKMAN. It just strikes me that if we begin to charge user fees, either they or somebody else could ultimately pick up the business, which is——

Mr. LATHAM. Well, they could come on as heroes in certain parts of the world by saying "we'll make it available to you for free" when the United States is charging. That's a factor.

Mr. GLICKMAN. Let me get to the issue of navigational errors. Does the military use any different systems for avoiding navigational errors than the civilian sector?

Mr. LATHAM. We use the Tacan system for precision navigation, local precision navigation, I'll call it. For overflight or long-range navigation, we essentially use the same systems that the civilian airlines or long-range aircraft would use.

Mr. GLICKMAN. So if you were flying a military aircraft on basically the same route as KAL 007 flew, from Anchorage to Seoul, you would use roughly the same—and I'm talking about not in a reconnaissance mission, but in a normal transport mission—you would use the same navigation systems?

Mr. LATHAM. Yes, sir. We might carry on-board navigators, which would be the other difference, perhaps, on certain flights. But other than that, the equipment would be pretty much the same.

Mr. GLICKMAN. What would the function of the on-board navigators be as opposed to the navigator that would be on a commercial flight?

Mr. LATHAM. I don't know——

Mr. GLICKMAN. For navigational purposes.

Mr. LATHAM. Just for navigational purposes, just to have a person there to update and check and use perhaps celestial checks and things of this nature.

Mr. GLICKMAN. Now, let me ask you about the over-the-horizon radar that's been referred to today. Could you tell me how that's used?

Mr. LATHAM. I heard that statement, and I don't know what over-the-horizon radar they're talking about. No such radar exists in the Far East. We have an experimental, over-the-horizon radar R&D facility—at Moscow, Maine by the way—which has been an R&D test facility, that is now going to be expanded to an operational site, with an 80-degree sector.

We also are planning to build a second over-the-horizon backscatter radar on the west coast of the United States. These two radars are being designed for Conus air surveillance and air defense purposes. There are no plans to put backscatter over-the-horizon radars somewhere else to do flight following across the ocean areas.

Mr. **Glickman**. One does not therefore exist on the mainland of Japan anywhere that we operate, or the Japanese Government operates, to the best of your knowledge?

Mr. **Latham**. To the best of my knowledge, there is no such system.

Mr. **Glickman**. I'm just trying to pin down the issue that the airline pilots and others have said, that there is a capability from the ground to determine where an airplane is several hundred miles away from a land mass. Given the fact that radio beacons move laterally, they can only go a certain distance. What you're telling me is that is not operational now.

Mr. **Latham**. We do not operate any such backscatter radar in Japan. I don't know about the Japanese Government. To the best of my knowledge, there is no such capability in the Far East.

Mr. **Glickman**. Do you, or did you have the capability of warning this airplane that it was off course, or a comparable aircraft, commercial aircraft that are flying down that route, that they are off course?

Mr. **Latham**. You mean does DOD have that capability? No, we don't, because we don't follow the commercial aircraft. They're just too many of them. We just cannot do that.

Mr. **Glickman**. Mr. McCandless?

Mr. **McCandless**. Thank you, Mr. Chairman. I have no questions.

Mr. **Glickman**. OK. Thank you very much, Mr. Secretary.

We have no further witnesses today, and this will conclude the hearing this morning.

[Whereupon, at 1:10 p.m., the subcommittee was adjourned.]

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